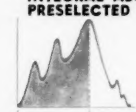
INSTRUMENTS and AUTOMATION

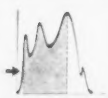
DISCLOSURE

TOTAL INTEGRAL

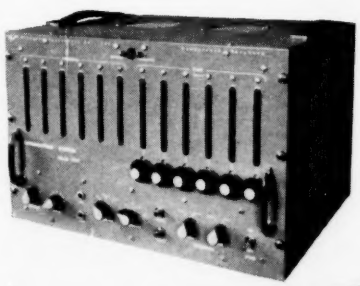
INTEGRAL ABOVE A PRESELECTED LEVEL



INTEGRAL DURING A PRESELECTED INTERVAL



INTEGRAL ABOVE A LEVEL AND DURING AN INTERVAL



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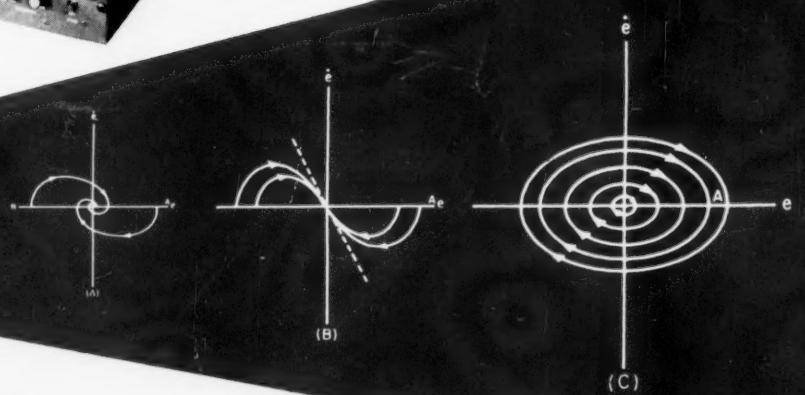

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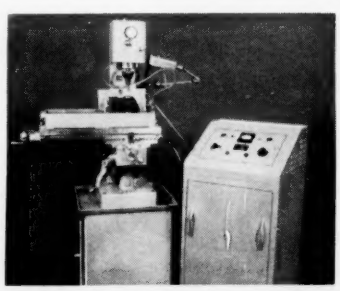

New Developments in Area Meters . . .
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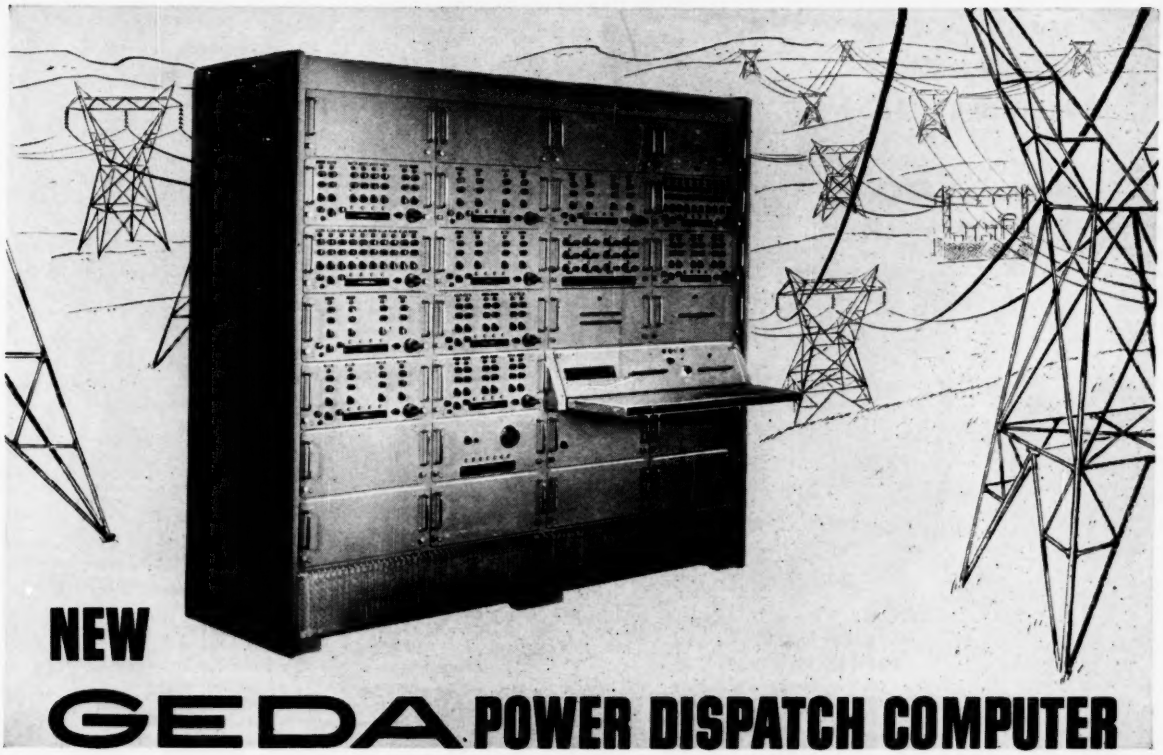

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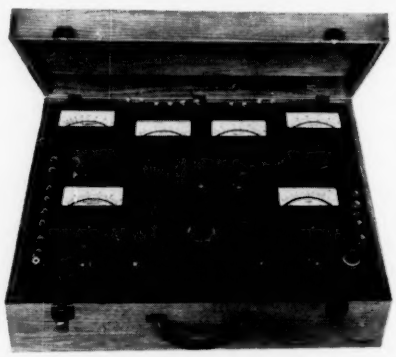

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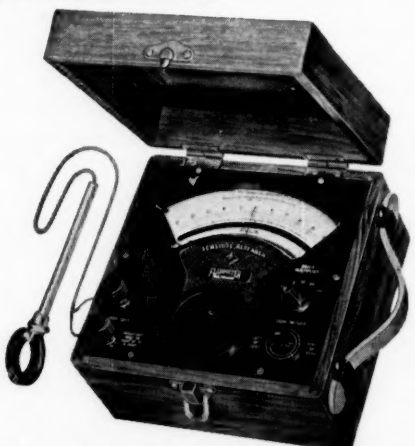

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Volume 30, No. 2
February 1957

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THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL SINCE JANUARY 1928

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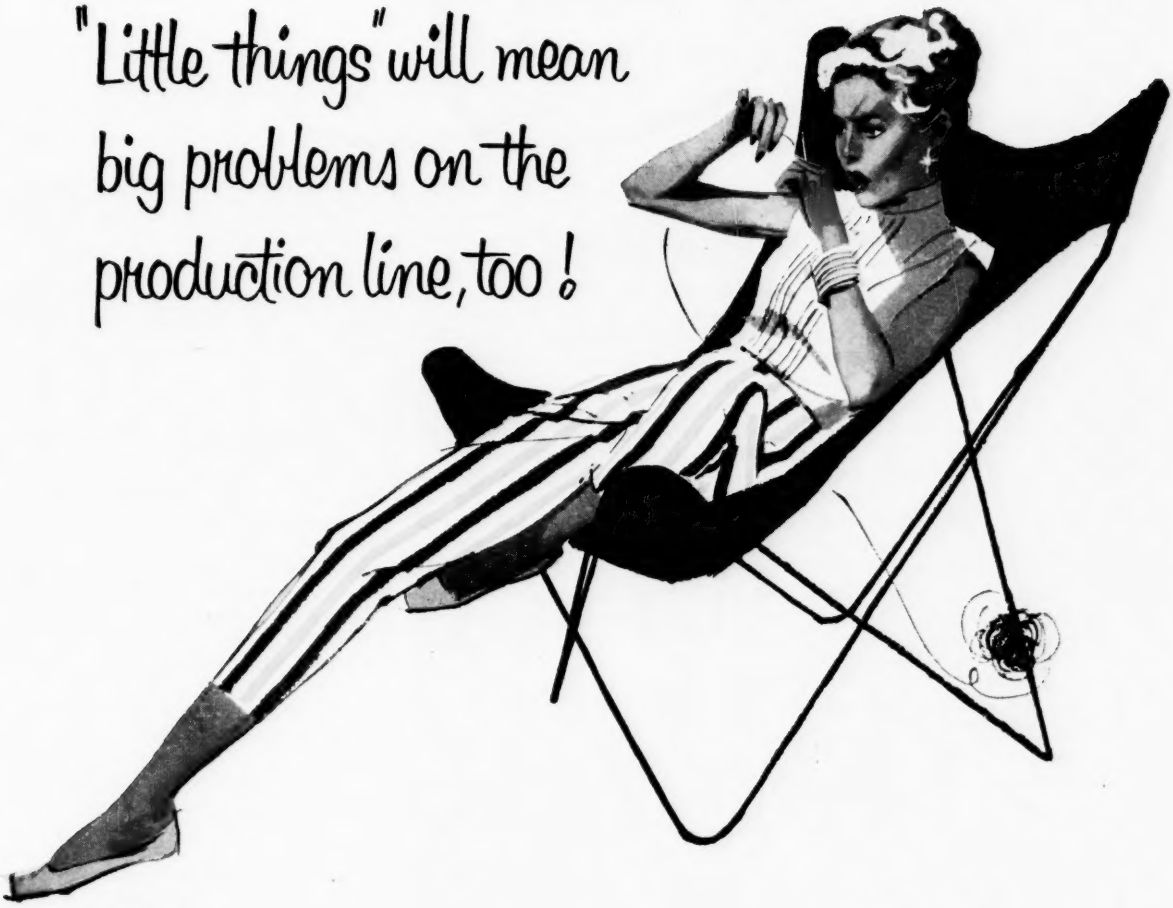

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INSTRUMENTS and AUTOMATION

Letters to the editor

REACTIONS TO OUR NOVEMBER, 1956 EDITORIAL:

Editor, I&A:

Your November 1956 editorial "The Effect of Automation on Productivity" is of special interest to me, for it helps me understand the potentials of my area of automation —computer control. I had not here-tofore differentiated between *productivity, production,* and *economy.* Now I see that the strong point of the computer control systems we work with and advocate, is that they make possible increased *productivity,* and that a continual increase in productivity is necessary, for competitive purposes. Whether increased *productivity* is used to increase *production,* depends on the market, not on the methods of attaining the productivity, such as automation or computer control.

The commonly voiced fear that automation (which is merely a means to increase productivity) may impair the national economy is illogical, for if it were true, then logically a reduction in productivity (such as by elimination of all mechanization) would improve our economy! Can anyone accept this absurdity?

I go along with your editorial that automation greatly affects *productivity,* (which is the *production* accomplished per unit amount of human effort or mechanical energy and equipment, and connotes efficiency). I also agree that *automation* has no direct effect on *production,* for production is paced by the market, the demand for the product, not by the effectiveness of the processes. Automation, an agent of productivity, is merely one element of the complex economy we live in, and can only have a minor, indirect effect on the economy. Automation can bring about neither doom, nor Utopia.

George H. Amber
Amber Brothers, Inc.
Consultants

Editor, I&A:

My reaction to your editorial can be very quickly and succinctly stated in that . . ."I could not disagree more."

Robert T. Sheen
Milton Roy Company

Editor, I&A:

Both as President of Brown Instruments Division of Honeywell and as President of SAMA it has been my feeling that automation has been a much abused subject—at least insofar as instruments are concerned. There are so many definitions, so many phases and kinds of automation in various people's minds that it is certainly not well understood in industry, let alone by the general public. We have had it abused by the public press; we have hade it used by labor as a club to help promote the guaranteed annual wage, and as you say it has been a glamour subject for conferences and conventions, trade associations and Congressional committees.

No one is more anxious than I to promote the welfare of the instrument industry, for our company stake is very great in it. I have tried to talk on this subject in a factual and down-to-earth fashion, pointing out particularly that hard facts and economics would largerly govern the speed and extent to which automation in any field progresses. I have great hopes for the future of instrumentation and even other forms of what is classified under the heading of automation—but I agree with you, we do no service to our industry by over-selling it in any place, and in particular before Congressional committees.

I think you are doing a good service to the industry in the editorial approach you have taken.

H. F. Dever
Brown Instruments Div.,
Minneapolis-Honeywell Reg. Co.

Editor, I&A:

I've read your editorial [Effects of Automation on the Economy] and like it very much. Your distinction between the words "productivity" and "production" is interesting and sound.

I'm sorry that the I.S.A. group which discussed automation with the Patman Committee in Washington did not have the opportunity to read your editorial before presenting their arguments to the committee.

R. A. Bristol
The Foxboro Co.

Editor, I&A:

I am enclosing a copy of the testimony I gave on December 13th before Representative Patman's Committee.

I found your editorial "The Effect of Automation" very interesting. It summarizes nicely the impact of automation on the entire economic structure. I do not know, however, if I would agree with some of the generalizations. Regarding these, I have the following comments:

1. I do not see how the instrument industry is falling into a trap that portends anything dangerous because we are giving publicity to "the effect of automation on our economy." Nor do I agree "that every word spoken on this subject implies that automation can cause or harm—the economic health," etc. In fact, I think the Congressional Investigation has been a most wholesome one, and I also think that the Congressional Committee should be complimented on the objectivity with which they approached the problem and on the conservatism expressed in their conclusions.

2. Everyone, including me, agreed that the effect of automation on the economy was going to be very favorable. It raises our standard of living, and I think the hearings brought out that everyone wants more automation, including labor.

3. The labor organizations agree that the overall effect of automation is favorable but that it will cause local disturbances of a temporary nature; and all they ask, frankly, is that collective bargaining means be set up to make sure that people who are displaced get a chance to find another job or get the right kind of training for the new jobs that are made available.

In conclusion, therefore, while I agree with your excellent points on productivity and production, I can't see where open discussion on such a high level can possibly do anything but good. That's the democratic process, and if we try to squelch the discussion, then we are likely to raise suspicions in the minds of labor and government.

A. F. Sperry
Panellit, Inc.

Agreed—All will be well—as long as times are good and jobs plentiful. But will

everybody be so gentle with us when the labor market changes? Have they not already been successful in placing us on the defensive? Do we really explain our effect on the economy by saying "it will be good"? Would it not be better to answer by asking the question—what factors do affect the economy?

Of course discussion must not be squelched. But we think discussion of the effect of any variable on the economy must begin with an analysis of just what does affect the economy—and in some order of importance. It is possible that automation would be at the bottom of a long list of economic factors—if it appeared on such a list at all. Without such a listing of factors, there is no framework within which to evaluate the excellent testimony offered by our industry spokesmen.

Final point: History shows that the first casualties when economic trouble occurs are objectivity and conservatism, as Mr. Silvey points out in the next "letter to the editor."

Editor, I&A:

I react to your excellent and tightly reasoned editorial in the November issue with its graphic triple headline. You make a most interesting challenge within the limits you set yourself. You are performing a splendid service to the instrument industry with your call to note that society could react in a blindly dangerous way in certain circumstances. We are a long ways from Salem's witch-burning, but not too deep beneath our mid-20th-century surface there are still some savage impulses. I want no burning of instrument men, or their products! We may have to struggle harder to use this heritage of wonderful instruments in more civilized ways.

But we of the labor unions have to point to both productivity *and* production. In recent published works I have prognosticated the agricultural situation to manufacturing . . . I have cited that any long and sad experience with so-called "surplus" food items is such a tying together of twins, which you are striving to sever.

Ted F. Silvey
National AFL-CIO
Department of Education
Washington, D. C.

Editor, I&A:

The editorial from the November 1956 *Instruments and Automation* quite thoroughly misses the mark.

In quoting from Mr. Greenburg's speech where you remark about "the presence of some other factors with an almost relentless influence" and then your repeated use of this word "relentless" shows that the public's apprehension about automation is far from understood.

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For more information circle **6** on inquiry card.

Company among others. The public has been lead to believe that "automation" is all that the pseudo science writers describe it as meaning . . . Rather than going into this further here, may I refer you to the recent paper by Mr. Bright of the Harvard School of Business Administration on "Myths and Fallacies of Automation."

The public is apprehensive of the tremendous uncomprehensible forces that could control our economy in a "relentless" fashion if "automation" were what magazines such as yours imply it to be . . . If instead of talking science fiction, our magazines were to print more reality about "automation" the public would no longer feel the oppression of this "relentless" effect on our economy. This is a psychosomatic problem that seems to have completely escaped the scope of the editorial.

Frank H. Rockett
Airpax Products Co.

Mr. Bright's comments on "Myths of Automation" are published in this issue. The theme of our editorial comment was to deplore public discussion of "The Economic Implications of Automation" because we are so very aware of the psychological factors involved—nor do we ever spend valuable editorial space on the science fiction aspects of automation, manless factories, etc. We feel like we are being confused with other publications.

Editor, I&A:

It was with a great deal of interest that I read the editorial comment on the subject of automation, and I can but agree that there is a great deal of confusion as concerning production and productivity.

It would seem to this writer that a much greater effort could be made to get across a clearer concept of automation, especially to the vast majority of readers who are neither engineers nor instrument people. In the great many contacts that I have had the feeling always seems to be that automation "replaces" workers and this always leads to a channeled discussion which has nothing at all to do with the subject itself.

I am passing it (the editorial) along to other interested people.

William N. Hesketh
The Haloid Co.

Editor, I&A:

You are to be congratulated on getting down to bedrock on the current discussions regarding the effect of automation on the economy [in your editorial "The Effect of Automation on The Economy"].

I have never been greatly impressed by the congressional investigations that have been held, as they always seem to fall short of their goal. In my opinion, our industry is capable of getting much better answers than government investigations will ever get.

In order to avoid more damaging discussions that are bound to come up on the subject, I suggest that you use larger italics in your comments to impress people more strongly. Please see that your editorial reaches a much larger list than your normal circulation would reach.

Keep pounding away on this. We agree with your thinking one-hundred percent.

Fred A. Lennon
Crawford Fitting Co.

Editor, I&A:

It would seem that automation has come of age, since it is apparently now to be classed in the congressional mind along with "interests" and other similar phrases . . . to be trotted out regularly when a politician feels he needs some kind of a medicine rattle to shake and to put across a particular purpose.

W. A. Kates
The W. A. Kates Co.

Editor, I&A:

We agree fully with your editorial about Congressional investigations of automation, and we should beware of such trends.

However, can it possibly be likened to the hue and cry of a couple of decades ago about technocracy, because the average congressman probably knows nothing about automation?

Ernest E. Olds
Size Control Co.

Editor, I&A:

Your editorial [The Effect of Automation on The Economy] is very interesting. I believe the general thinking in our field, and certainly within our own company, would agree with you that Automation certainly does not threaten the economic health of our country. Automation, by improving productivity, actually should in the long run contribute to the well-being of this nation.

S. E. Voran
The Parker Appliance Co.

Editor, I&A:

Pursuant to your editorial on the Wright Patman Congressional Committee and its looking into automation, my comment is that someone tell Mr. Patman that he look regularly at automation to see whether it is being consummated speedily enough. With the known race between Russia and the United States for industrial productivity, the only solution for the United States staying ahead in this race is increasing use of automation and automatic control throughout American industry. Thus, far from it being a menace to our economic health, it is in reality a "must." In other words, something that American industry *must* do; it has no choice in the matter. Russia is already stealing ahead.

Possibly some publicity via TV, radio, newspapers, etc. along the lines of an editorial approach would be most helpful. Possibly member companies of the instrument and control fraternities could contribute financially toward the execution of such a program. Somebody, you, SAMA, the ISA, should launch such a program.

C. C. Roberts
Askania Regulator Co.

Editor, I&A:

My fear is that the term "automation," through the efforts of writers more concerned with sensational stories and the salability of their copy, may, for somewhat the same reasons, suffer as did "efficiency engineering" in the late teens and early twenties.

While this may not qualify as news to those as informed and as alert as are you and your associates, I mention it with the thought that sometime soon it may be feasible for you, as publishers, to inaugurate a movement that would rally those who are seriously interested in instrumentation in a campaign to preserve "automation" from both adverse legislation and public disfavor.

George W. Kelsey
B-I-F Industries, Inc.

The dilemma is how to "campaign" and what issues to select. Should unemployment ever become a national problem, what would be the end result of a national campaign dedicated to the proposition that automation creates jobs? Nor is the answer silence. Our industry now has a vested interest in proving—by systems analysis—just what economic factors enter into the closed-loop economic state, including the amount and type of feedback necessary to maintain economic health and stability.

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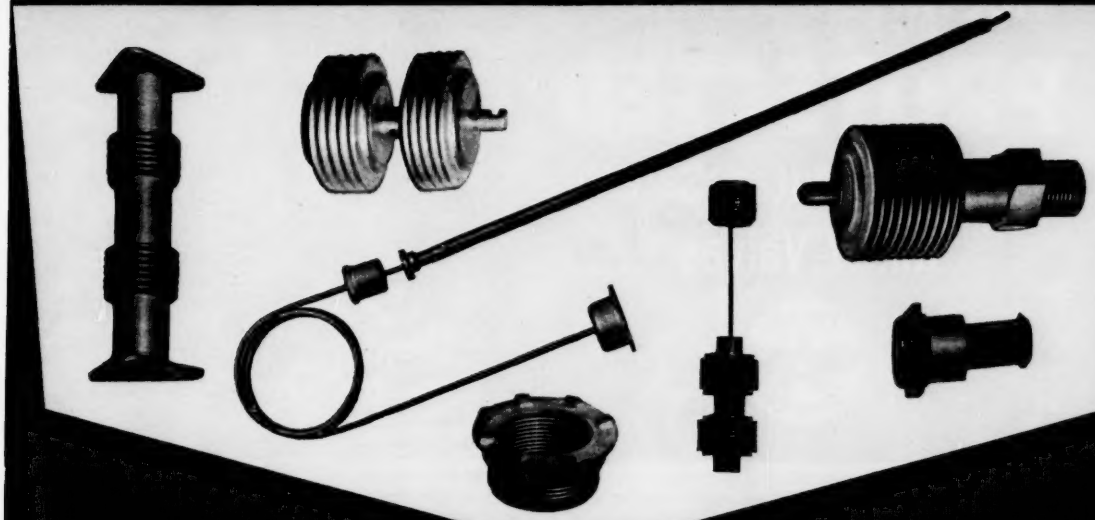


No matter why or how the bellows principle enters into an assembly, Fulton Sylphon can assemble the right bellows and related accessories or mountings into a complete device that meets your specifications. In doing this Fulton Sylphon offers important design help, specialized skill in joining bellows with other members, and modern production facilities for on-time deliveries.

BELLOWS FOR INSTRUMENT ASSEMBLIES

are available with diameters, lengths, strokes, spring rates, metals and charges to provide a wide range of movements in high or low pressure systems. In all applications the exclusive Sylphon® bellows assures continuing accuracy and safety of operation. For one thing, cold-working production methods give it maximum resiliency for withstanding repeated cycling. In addition, its *seamless* design and the availability of multiple plies enable the Sylphon bellows to better resist pressure and other conditions.

Send for Bellows Catalog CL—1400

Mr. Controls

Robertshaw-Fulton

CONTROLS COMPANY

FULTON SYLPHON DIVISION, Knoxville 1, Tenn.

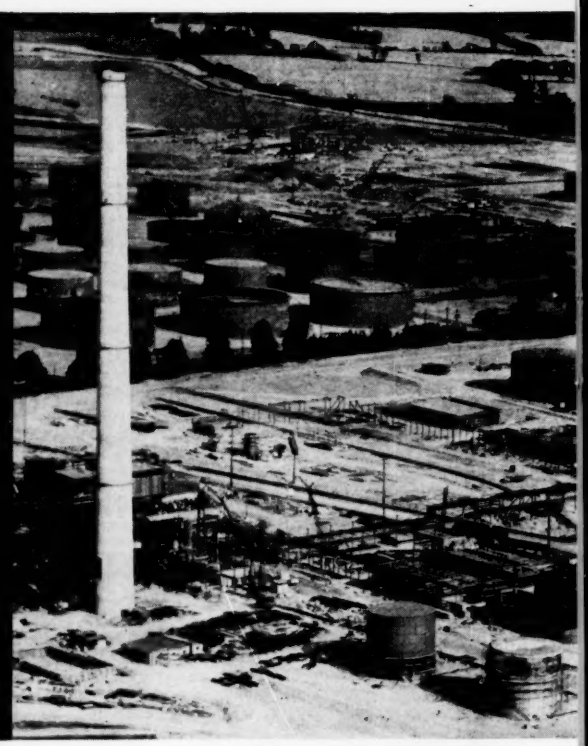
For more information circle **8** on inquiry card.

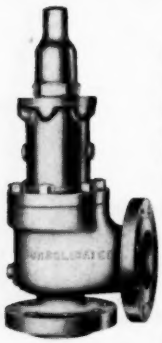
GIANT

TIDEWATER REFINERY

PROTECTED

by Consolidated Safety Relief Valves





The world's most modern refinery will soon go on stream. It is the gigantic Delaware Flying A Refinery of the Tidewater Oil Company just 15 miles south of Wilmington. C. F. Braun & Co., engineering contractors, built the new plant on the 5000-acre site. Many of the processing units are unequalled for size and capacity anywhere. In around-the-clock operation, 130,000 barrels of crude of any kind can be processed daily. Tidewater engineers incorporated the most advanced design and equipment to provide the greatest flexibility, economy and safety.

Consolidated Safety Relief Valves are "sentinels of safety" in this mammoth "refinery of the future". Peak performance and consistently positive valve action are assured even where discharge lines are long or there is low "superimposed" back pressure in the relieving system. They provide the absolute protection so vital in petroleum processing and on product storage facilities.

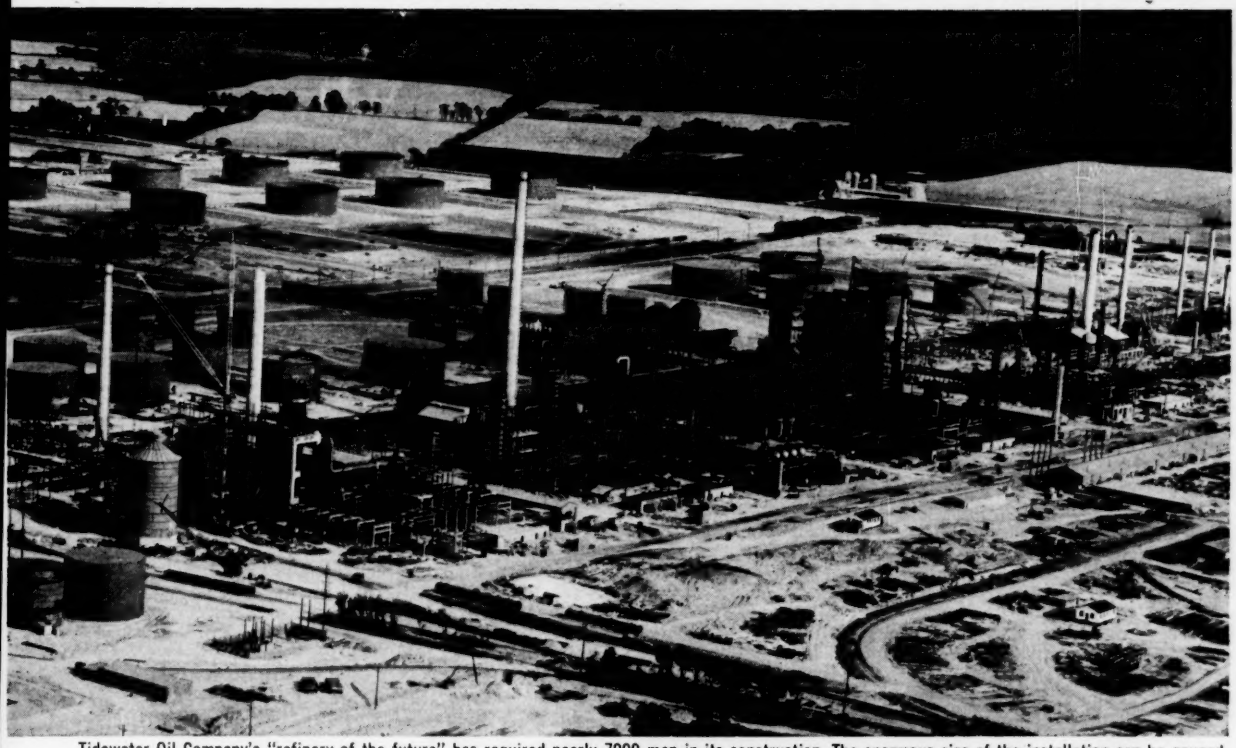
Wherever Consolidated Safety Relief Valves are used, flexibility of application greatly reduces inventory costs. They are "2 in 1" valves. Interchangeability is so highly perfected that you can convert the Standard type to the Balanced Bellows Seal type *in the field* simply by installing a stainless steel sealing bellows. You can readily interchange these valves with those of other manufacturers: inlet and outlet center-to-face dimensions are standardized. Consolidated Safety Relief Valves also have fewer functional parts than comparable valves. The seating surface is optically-ground flat. From every standpoint, you can count on lower inventory costs and easy maintenance.

Write for full details about the complete reliability and all-around economy of Consolidated Safety Relief Valves. Both Standard and Bellows type are available in sizes and pressures to meet requirements today and tomorrow. Ask for Catalog 1900.

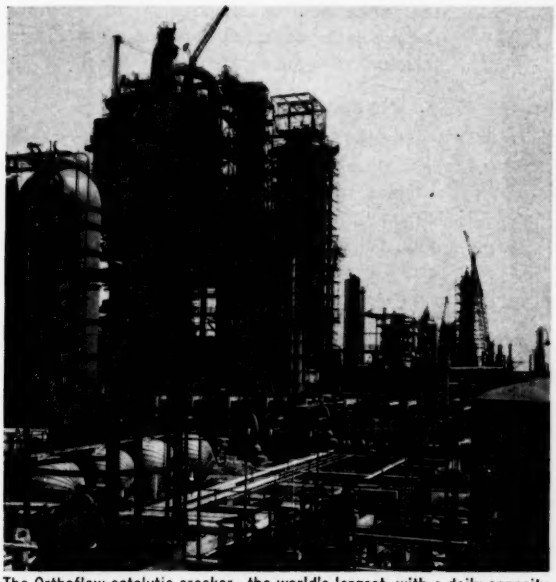
CONSOLIDATED SAFETY RELIEF VALVES

CERTIFIED AND APPROVED. Both Standard and Bellows Valves are approved under API-ASME and ASME Unfired Pressure Vessel Codes and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

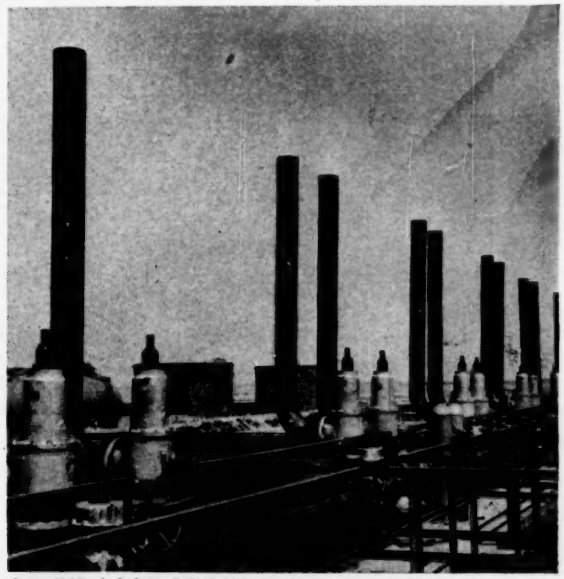
For more information circle 9 on inquiry card.



Tidewater Oil Company's "refinery of the future" has required nearly 7000 men in its construction. The enormous size of the installation can be gauged by the 500-foot high power station stack at the extreme left. To the right of the stack are, in order, the fluid coker, the sulphur recovery plant, the crude unit, the Orthoflow fluid catalytic cracker and other processing units. The Delaware Flying A Refinery's 7,000,000 barrel capacity "tank farm" is in the background. The refinery's processing units occupy 450 acres of the 5,000-acre site.



The Orthoflow catalytic cracker—the world's largest, with a daily capacity of 102,000 barrels—is equipped with Consolidated Safety Relief Valves.



Consolidated Safety Relief Valves also stand guard atop the propane storage bullets at Tidewater's Delaware Flying A Refinery.

A PRODUCT OF MANNING, MAXWELL & MOORE, INC.

TULSA, OKLAHOMA

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.*, 'HANCOCK' VALVES, *Watertown, Mass.*, 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.*, AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.*, "SHAW-BOX" AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.* **In Canada:** *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario.*

For more information circle **9** on inquiry card.

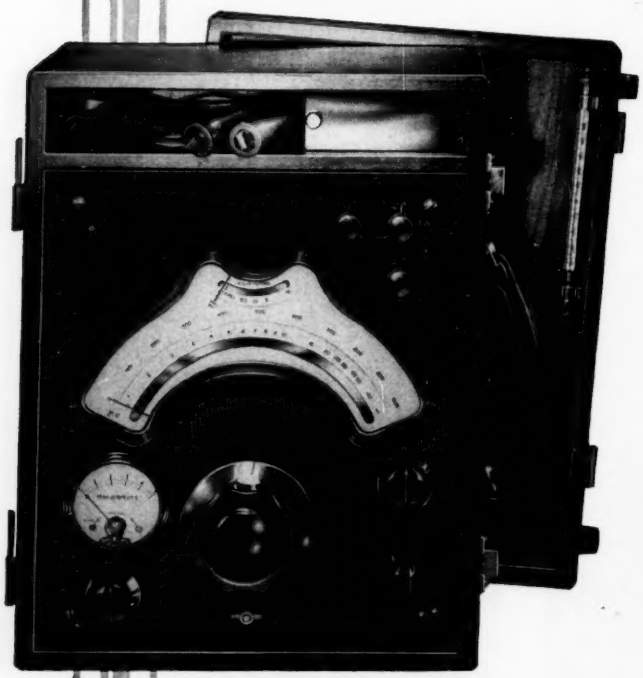
AN ACCURATE, PORTABLE, MULTI-FUNCTION INSTRUMENT

THE LEWIS *PORTABLE* TEST POTENTIOMETER

for Service Testing Exhaust Temperature Measuring Systems

Developed for use by field service engineers of a leading engine manufacturer, the Model 13P05 Test Potentiometer has proven its serviceability in desert heat and arctic cold at maintenance bases on many points of the globe.

FOUR PRECISION INSTRUMENTS IN ONE!



Model 13P05

For dependable maintenance, use test equipment made by the manufacturer of the components to be checked.

A PYROMETER-POTENTIOMETER
for measuring exhaust thermocouple temperatures that is truly portable with a sturdy pivoted galvanometer and without a standard cell. Accurate automatic electrically operated cold junction compensation permits this instrument to be used in ambient temperatures from below freezing to plus 120°F. Mirror scales with precise hand-drawn graduations and knife edge pointers insure accurate readings from zero to 1000 degrees Centigrade.

A LOW RANGE OHM-METER
with a widely spaced, hand drawn scale for checking the resistance of leads, thermocouples and balancing resistors to insure correct adjustment to match external resistance requirements of exhaust temperature indicators, either eight or twenty-two ohms.

A KILO-OHM METER,
energized by a 67½ volt battery for checking insulation resistance of lead-wires and thermocouples. Due to the potential applied, this circuit is more effective in detecting flaws than conventional ohm meters. A hand-drawn scale is clearly marked in kilo ohms resistance.

A THERMOMETER TESTER
for precise scale error checks of exhaust temperature indicators having either eight or twenty-two ohms external resistance. A controlled power supply energizes the indicator under test, through the correct series resistance, and the zero to 1000°C temperature scale is used as a reference standard. Recommended for use in adjusting exhaust indicators in accordance with ambient temperature, with power applied for 700°C, through the proper resistance. A liquid-in-glass thermometer and flexible test leads are supplied with each instrument.

LEWIS ENGINEERING CO.

NAUGATUCK, CONNECTICUT

For more information circle **10** on inquiry card.

INSTRUMENTS and AUTOMATION Trends

Sales of closed-circuit TV is estimated for 1956 at $6 million by F. P. Barnes, marketing manager, G-E; but sales are expected to reach $75 million within 10 years.

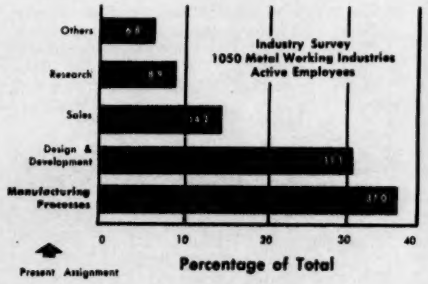
Transistor production was 3 million units in 1955; 13 million units in 1956; is expected to reach 30 million units in 1957.

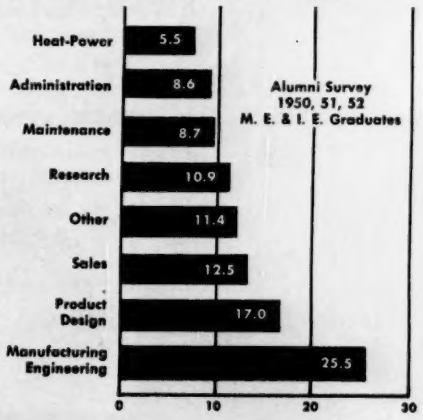
1957 preview by L. B. Davis of GE Electronic Components Div.:
Semiconductor sales should double their 1956 volume of $32 million, with largest growth in computers.
Receiving-tube industry should reach $400 million, with $300 million commercial and $100 million industrial and military.
Largest expansion-industrial and military.
Power tubes should increase 10% due to automation, plant expansion, domestic cooking and industrial heating.
Increases will occur in printed wire boards, encapsulated assemblies, leadless ceramic capacitors, etc.

Air-to-air guided missile "Sidewinder," employing heat-seeking (infrared) guidance, is now in operational use in both Mediterranean and the Western Pacific.

1954 Census of Business reports that there were 10,139 establishments in the U.S. at the end of 1954 engaged in industrial machinery, equipment, and supplies, with sales of $4.6 billion, up 55.6% since 1948.

The 35,000-member American Society of Tool Engineers (ASTE) came up with interesting statistics on Where do Engineers Work in Industry. Results shown in charts are averages from surveys conducted among alumni (1950-52) of mechanical and industrial engineering classes at 5 well-known universities; confirmation was sought in an industry survey of more than 1000 companies for the same type of employees. Both surveys show a predominance in demand for manufacturing activities.





NEW — UNIVERSAL CABINET RACKS

PAR-METAL ELECTRONIC HOUSINGS

WITH OPEN SIDES AND DETACHABLE SIDE PANELS

Adaptable TO GROWTH REQUIREMENTS

The above unit is our Type "*PR*" (with rear door only) "Universal Cabinet Rack." Type "FR" (shown with detachable side panels *affixed*) has both front and rear doors.

PAR-METAL Types "PR" and "FR" Universal* Cabinet Racks are made with *Detachable Side Panels* in order to assure flexibility for your future needs.

Because these are STANDARD UNITS, you get custom-quality at economical cost. They may be used *singly* or in a *group arrangement.*

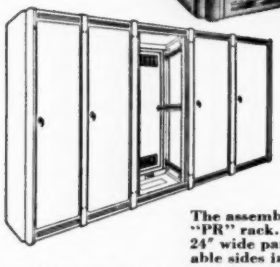
Made in these dimensions:

Heights: 48⅛", 67⅜", 76⅛" and 83⅛".
Depths: 18" and 24".
Panel Widths: 19" and 24".

Built for Dependable Service

While incorporating new features of versatile assembly, there has been no sacrifice of *structural rigidity.* ALL PAR-METAL RACKS *are substantially welded* and *reinforced* for diversified industrial use.

STANDARD ACCESSORIES: Vertical Side Supports, Sliding Shelves, Rack Mounting Chasses, Bases, Roller Trucks, etc., are available as standard equipment.



The assembly of 5 racks shown at left has 4 Type "FR" and 1 Type "PR" rack. Equal height racks may be intermixed with 19" and 24" wide panels. The end panels of the assembly have the detachable sides installed. They are quickly removable.

* Universal Cabinet Racks are also available with fixed side panels.

PAR-METAL PRODUCTS CORP.

Metal Housings for Electronic Apparatus

32-54 49th Street • Long Island City 3, N. Y.

Mail this coupon for our Latest Catalog today.

Par-Metal Products Corp.
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We are interested in "Universal Cabinet Racks."
( ) Mail a copy of your latest catalog to:—

Name..... Position.....
Address.....
Company.....
City..... Zone.... State.....

For more information circle **7** on inquiry card.

Inquiries

These inquiries, representing problems facing readers of **Instruments & Automation,** are published as a free service to our readers.

High Speed Solenoid

Engineer of plywood manufacturing company seeks "high speed solenoid strong enough to activate a small saw of the saber saw type with probably 1/32" stroke" and with 3 to 5 thousand strokes per minute. A-192

Repeating Cycle Timer

Maintenance engineer is interested in bids for an automatic repeating cycle timer. A-193

Automatic Sampler

Engineer in oil refinery seeks addresses of manufacturers of an automatic sampling device for natural gasoline plant product with from 50 to 80 psig vapor pressure. A-194

Telescriber

Purchasing superintendent in chemical company seeks "Telescriber" such as the Telautograph. A-195

Surface Temperature Measurement

European manufacturer of steel tubes requires pyrometer to measure surface temperature (approx. 1400°C) of steel tubing, ¼" to 4", along joint. Tubing is fabricated from strip with the two edges electrically heated in a zone 2 to 3 mm wide, and pressed together after temperature measurement. A-196

Moisture in Talc

Quality control engineer of ceramics manufacturer seeks instrument to determine moisture content of talc with ¼% accuracy. Range: ½ to 20%. A-197

Helmholtz Coil

Alaskan manufacturer seeks information on "manufacture and circuitry of a Helmholtz coil for testing magnetic-flux valves by creating a variable magnetic field about the instrument". A-198

Automatic Hole Gaging

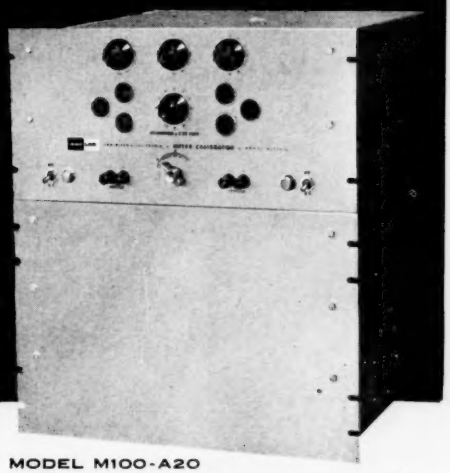
Plant Engineer of wire die manufacturer wishes contact with company that can supply gage for automatically measuring hole size in diamond die with accuracy of 0.0001". Hole sizes vary from 0.0004" to 0.075". A-199

High-Power Servo

Superintendent of testing department of electric manufacturing plant seeks servo system with linear positioning response to drive group of direct-writing oscillograph pens (2 lb), having a full travel of 1.5", at 0 to 200 cps. Available signal input is 20 watts; operating power may be 25 kw. A-200

Need accurately controlled

POWER?



MODEL M100-A20

USE KAY LAB ABSOLUTE DC POWER SUPPLIES AND METER CALIBRATORS

— STANDARD CELL ACCURACY

— 0.01% STABILITY

— <0.5 MILLIVOLT RIPPLE

— 0.002% REGULATION

— <0.2 MILLISEC RESPONSE TIME

— 21 MODELS: 0-2000V, 0-2 AMP

KAY LAB's unique chopper stabilized circuit constantly compares the output with an **internal standard cell,** providing stability, accuracy, and dynamic characteristics **without equal.** Direct reading calibrated dials provide instant voltage selection. Both current and voltage regulated models available. Ideal wherever a general purpose precision voltage or current source independent of line or load is required . . . for laboratory and production meter calibration, computer reference, secondary standard, DC bridge supply, transistor testing, circuit design, nucleonics instrumentation, null voltmeter . . .

SPECIFICATIONS

POWER SUPPLY: Short Time Stability (several hours), ±0.005%—Long Time Stability, ±0.01%—Output Voltage Calibration, ±0.02%—Output Impedance, < 0.01Ω at DC, <0.05Ω to 200 kc—Output Hum and Noise, < 0.5 millivolt—Load Regulation Factor, ±0.01%—Line Regulation Factor, ±0.002%.

METER CALIBRATOR: Same as Power Supplies with following exceptions for models which go to zero volts: Calibration Tolerance, ±0.05%—Hum and Noise, < 2 millivolts—Line Regulation Factor, ±0.01% of full scale.

KAY LAB

Representatives in all major cities

Write, wire, phone today for demonstration

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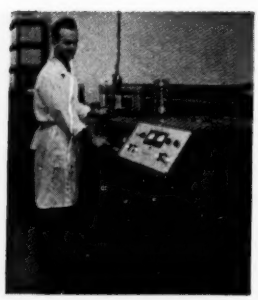
For more information circle **12** on inquiry card.

Recognized leaders in analysis

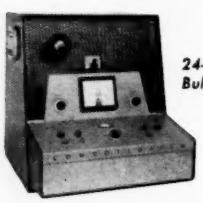
38-202 Process Refractometer
Bulletin CEC 1833-X2

The science of qualitative and quantitative analysis by mass spectrometry was pioneered and developed by Consolidated Electrodynamics Corporation. CEC's 21-103C Mass Spectrometer analyzes complex mixtures at unequalled speed and accuracy. Its extreme sensitivity (1/1000 mol per cent) plus wide range (from mass 2 to mass 700) offers maximum versatility. The compact 21-620, utilizing the "Cycloidal Focusing" principle, is ideal for accurate readings from mass 2 to mass 150. CEC's mass-spectrometer-type leak detectors find use in hundreds of industrial applications. The 24-110 Leak Detector registers trace quantities of helium as small as one part in two million parts of air, and the low-cost portable 24-210 detects one part of helium in 300,000 parts of air.

CEC's vapor-phase Chromatograph provides fast, accurate analysis of almost any mixture, including liquids with boiling points as high as 325° C. Its exclusive *heated* sampling valve gives superior reproducibility by eliminating both operator error and sample contamination. For sulfur-compound detection, CEC's Titrilogs are highly sensitive, offer a wide range and instantaneous response. Both the stationary and portable models report sulfur-compound concentrations as low as 0.1 ppm or 0.005 grains per 100 cubic feet.

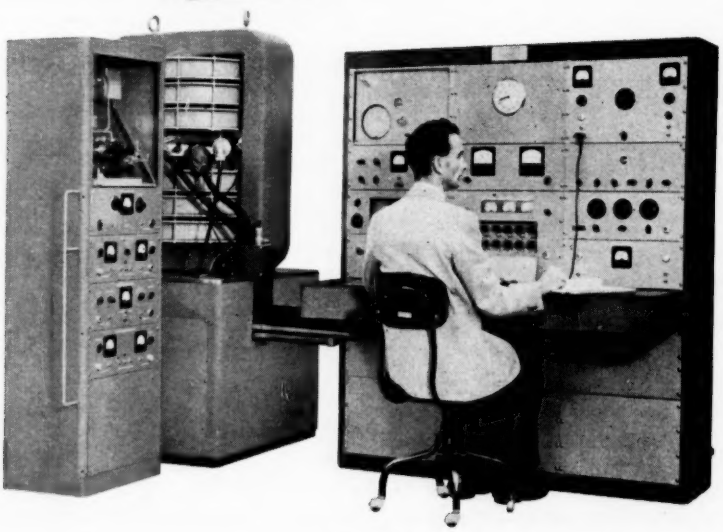


24-110 Leak Detector
Bulletin CEC 1838-X6



24-210 Leak Detector
Bulletin CEC 1830-X14

26-103 Titrilog
Bulletin CEC 1810-X10



21-620 Mass Spectrometer
Bulletin CEC 1824-X9

21-103C Mass Spectrometer
Bulletin CEC 1800-X23

For more information circle **13** on inquiry card.

and process control

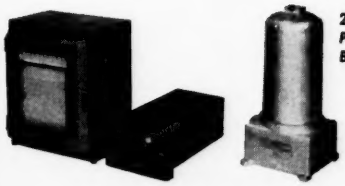
Consolidated

leading manufacturer of electronic instrumentation and high-vacuum equipment

ELECTRONIC INSTRUMENTS
Recording Oscillographs
Galvanometers
Direct-Writing Oscillographs
Oscillogram Processors
Analog Computers
Data Reduction Systems

VACUUM EQUIPMENT
Pumps
Gauges
Valves
Instrumentation
Components
Leak Detectors

26-201 Chromatograph
Bulletin CEC 1831-X13



26-202
Process Chromatograph
Bulletin CEC 1836-X2

Custom engineered for the petroleum and chemical industries, the Consolidated-Philips Process Refractometer measures the difference between a liquid standard and a liquid sample from a process line. This explosion-proof, dependable unit quickly pays for itself through increased product yield and product quality. CEC's *new* Moisture Monitor gives accurate measurements down to one part per million of moisture present in gaseous mixtures. Equipped with an adjustable and accurate flow regulator and a meter calibrated in ppm, the 26-301 permits precise readings from 0 to 1000 ppm by means of a 5-step attenuator.

26-301 Moisture Monitor
Bulletin CEC 1834-X9

For complete information—applications, specifications and features—please write for the specific Bulletins listed in this advertisement . . . or contact your nearby CEC field office. Your best investment for product improvement is a Consolidated instrument.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

NATIONWIDE COMPANY-OWNED SALES & SERVICE OFFICES

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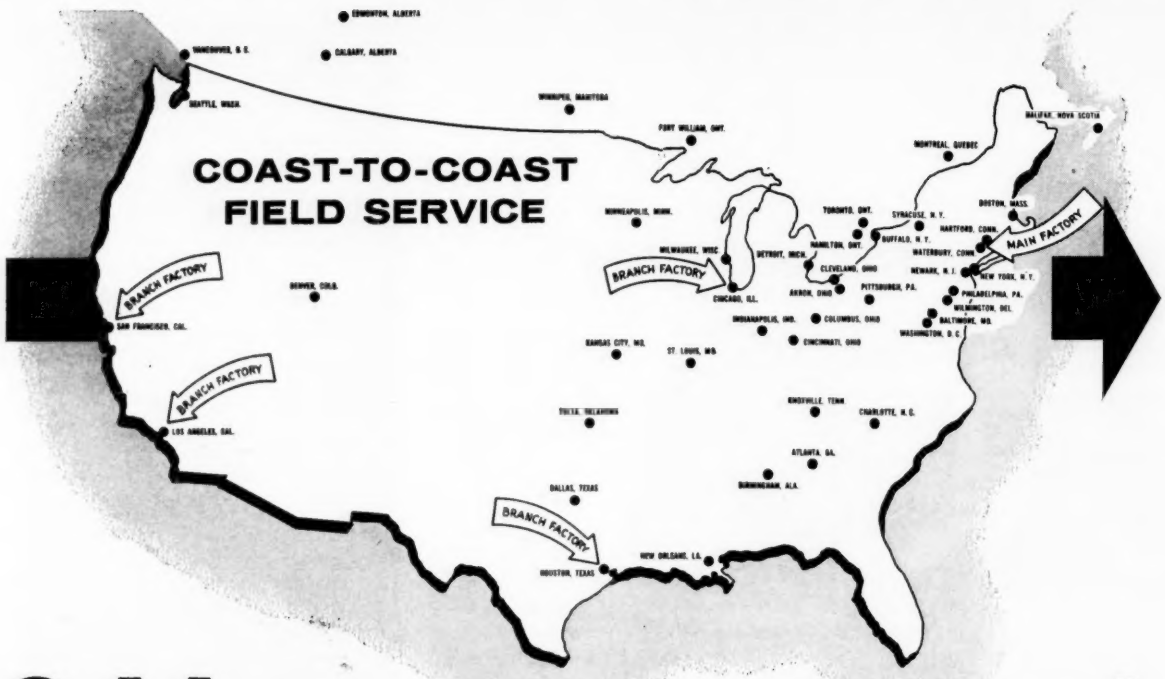

8 big extras you get

WHEN YOU BUY

Bristol Instruments

Here's how Bristol can help you with an integrated, nationwide service organization

FACTORY REPAIRS AND SERVICE are available on Bristol instruments at San Francisco, Los Angeles, Chicago, Houston, and Toronto, as well as at Waterbury. Each reconditioned instrument carries a "new" guarantee.

EDUCATION FOR AUTOMATION. Instruction is offered in THE BRISTOL INSTRUMENTATION SCHOOL for customers' engineers and technicians on latest techniques in instrumentation. Widely attended, too, by professors from the leading technical schools.

For more information circle **14** on inquiry card.

1. FIELD ENGINEERING. Bristol field engineers are ready to serve you from offices located throughout the United States and Canada. Years of training and experience in applying instruments in all types of plants enable them to recommend the equipment best suited for your job. They call at your plant, without obligation or cost, to assist you in planning proposed instrument installations.

2. APPLICATION ENGINEERING. Our application engineering department includes specialists in every type of measuring or controlling instrument. These men are completely familiar with the abilities, limitations, and accessories of their particular specialty. And they know the methods of installation and operation that assure the best possible performance.

3. PROCESS SPECIALISTS. Process instrument experts, each a specialist in a particular industry, are ready to advise you on up-to-the-minute instrument systems for tough or unusual processes. Their correctly planned installations and accurately specified instruments save delivery and installation time and make for successful operation.

4. FIELD CHECK-UP SERVICE. A nation-wide staff of factory-trained, widely experienced Bristol service engineers gives you personal assistance in servicing your Bristol instruments. For a reasonable rate, they install, check, adjust, and inspect Bristol instruments in your plant. They are available on short notice—often within a few hours. Regardless of your location, Bristol service is "on call" at any time to help you get the most out of your Bristol instruments.

5. PERIODIC CHECK-UP SERVICE. A systematic plan of preventive maintenance and repair is available to users of Bristol instruments to keep their equipment in good operating condition. In this plan, a Bristol Service Engineer calls at regular intervals to inspect the instruments and make minor repairs before serious wear or damage can take place. These preventive measures guard against breakdowns at critical periods.

6. FACTORY REPAIR SERVICE. Factory repair facilities at San Francisco, Los Angeles, Chicago, Houston, Waterbury, and Toronto are available to repair, recondition and remodel Bristol instruments. All phases of fabricating, testing, calibrating, repairing, and remodeling Bristol instruments are performed at these branch factories by trained workmen, experts through years of experience in our production methods. Only genuine Bristol parts are used. *Each instrument reconditioned in any branch factory carries a new instrument warranty.*

7. FAST PARTS SERVICE. Service parts, such as may be needed in emergencies, are stocked by our branch offices. Everything possible is done to ship service parts and accessories promptly.

These big extras you get with Bristol instruments are good reasons—over and above outstanding basic instrument quality—why every Bristol installation gives such high accuracy and precision performance over an extremely long service life. When you buy Bristol instruments you can get service when you want it, regardless of where you are located. To find out more about Bristol instruments or service, write: The Bristol Company, 113 Bristol Road, Waterbury, Connecticut. 6.75

8. WRITE FOR BRISTOL TECHNICAL DATA—reputed to be the most outstanding present-day source of Instrument Engineering Data on the following subjects:

- Absolute pressure gauges
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- Draft gauges
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- Electrolysis survey recorders
- Electronic bridge instruments
- Electronic potentiometers
- Flow meters—Mechanical and Electric
- Gauges—pressure, vacuum, draft, absolute pressure, liquid level
- Humidity controllers and recorders
- Liquid level gauges
- Load totalizing with Thermoverter*
- Metameter* Telemeters
- Motion, operation, running-count and running-time recorders
- Production recorders
- pH control instruments
- Pneumatic transmission systems; Metagraphic and Metavane*
- Potentiometers, electronic
- Pressure and vacuum gauges
- Process control instrumentation
- Pyrometers
- Recorder charts
- Resistance thermometers
- Smoke density recorders
- Specific gravity instruments
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- Thermometers
- Time-program controllers
- Valves, automatic

*T.M. Reg. U. S. Pat. Off.

Ask for information on the subject of interest to you. We'll be glad to send it.

BRISTOL

TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **14** on inquiry card.

Compact amplifier-voltmeter with millivolt sensitivity

High frequency extended range oscillator

Low-distortion, wide-band bridge type signal generator

BIG PERFORMANCE IN SMALL PACKAGES

Type 346 double-duty meter instrument. Serves simultaneously as vacuum tube voltmeter and highly sensitive a-c voltage amplifier.

METER RANGES: 0.001, 0.003, 0.01, 0.03, 0.1, 0.3, 1.0, 3.0, 10.0, 30.0, 100.0, and 300.0 volts full scale. **ACCURACY:** ±3%, 20 cps to 1 mc, ±5%, 10 cps to 2 mc. **STABILITY:** ±1% at any line voltage between 105 and 130 volts ac. **INPUT IMPEDANCE:** 10 megohms – shunted by 24 uuf. **AMPLIFIER:** Maximum voltage gain 1000; maximum output voltage 1 volt. **OUTPUT IMPEDANCE:** 600 ohms resistive. **HUM AND NOISE:** One minor division max. **OVERLOAD:** Automatic overload protection. **POWER REQUIREMENTS:** 117 volts ±10%, 50-400 cps 40 watts. **SCALE:** Illuminated 4¼" damped meter movement. **DIMENSIONS:** 6½" high, 4¼" wide; and 7½" deep overall. Weight: 6½ lbs.

PRICE **$200***

Type 347 extended range oscillator featuring extended high frequency range, low waveform distortion, constant level output and remarkably small physical size.

FREQUENCY RANGE: 18 cycles to 1.1 mc in five overlapping ranges. **DISTORTION:** Total harmonic distortion of waveform less than 2/10 percent when operated into 10K ohms or higher load. **CONSTANT OUTPUT:** Output voltage constant to within ±½ db from 18 cps to 200 kc for any output over 0.1 volt. High range ±2 db. **OUTPUT LEVEL:** 10 volts open circuit. Maximum load current: 4 ma. rms. **OUTPUT CONTROL:** Logarithmic control calibrated in volts. **INTERNAL IMPEDANCE:** Approximately 400 ohms. **CALIBRATION ACCURACY:** ±2% (+1 cycle) from 18 cps to 210 kc, +10% to 1.1 mc. **STABILITY:** ± 0.3% for line voltage range of 105 to 130 volts, and ±0.5% for temperature range of 0 to 50°C. **HUM AND NOISE LEVEL:** 3.0 Millivolts or 60 db below output signals, whichever is greater. **DIMENSIONS:** 6½" high, 4½" wide, 6" deep overall. Weight: 6 lbs.

PRICE **$150***

Type 348 signal generator provides low distortion sinewave signals between the frequencies of 0.9 cps and 510 kc. Just right for design investigations of magnetic amplifiers, servomechanisms, computers and general laboratory and field use.

FREQUENCY CHARACTERISTICS
RANGES: 0.9 cps to 510 kc in six ranges. **STABILITY:** ±0.5% for frequencies up to 100 kc for line-voltage variations 105 to 130 volts and temperature within 0 to 50°C. **CALIBRATION ACCURACY:** ±2% (+½ cycle) above 10 cps; ±5% below 10 cps. **DISTORTION:** Less than 0.1% over most of the useable range rising to less than 0.3% at 30 cps.

AMPLITUDE CHARACTERISTICS
OUTPUT LEVEL: 50 volts, ±10% 2 watts or 40 ma maximum. **OUTPUT RANGES:** Continuously variable from 0 to 0.05V.; 0.5 volts; 5.0 volts; 50.0 volts. **STABILITY:** ±0.5 db referred to 1 kc over the entire frequency range. **OUTPUT IMPEDANCE:** At the 50 volt output range – 6 ohms in series with 1000 microfarad; 5 volt output range–6 ohms in series with 1000 uf; 0.5 volt range–55 ohms; 0.05 volt range–6.2 ohms. **POWER SUPPLY REQUIREMENTS:** 117 volts ac, ±10%; 50-400 cps, 110 watts. Fuse protection; 1.6 amperes, slow-blow. **DIMENSIONS:** 9-7/8" high, 7-5/16" wide, 10-11/16" deep overall. Weight: 19 lbs.

PRICE **$325***

** Price slightly higher in 50 cycle areas.*

DU MONT®

DESIGNS FOR THE TIMES

Oscilloscopes • Pulse Generators • Signal Generators • Vacuum Tube Voltmeters • Electronic Switches
Recording Cameras • Industrial Television • Scanning Systems • Electronic Components • Pulse Transformers

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Technical Sales • ALLEN B. DU MONT LABORATORIES, INC. • Clifton, N.J.

For more information circle **15** on inquiry card.

Who Put The "P" In Pneumatics?

Panhandle Pete

"The stag at eve had drunk his fill,
Where danced the moon on Monan's rill,
And washed his teeth and brushed his hair
With a great big breath of the fresh mountain air."

Apologies to Sir Walter

Do your pneumatic controls stink? Are you bothered with kruddy air that fouls up your working area with the odor of burnt oil or old rubber boots? Does your shop smell like the army had walked through it in their bare feet? Does your air remind you of eau de stock-yard instead of pine needles and new-mown hay? Well, relief is in sight and you can jump up and down with anticipation.

According to the abstract which has come to my attention, that well-known manufacturer of gas analyzers and other electronic equipment, the Wallace Electronic Service Company of New Somerset, Jefferson Co., Ohio, is now producing an air purifier, the de-P, for industrial use. Under the leadership of Dr. Otto U. Alles, Director of Research, this problem has been researched to hell and gone, and two models are offered. Thus a new tool is made available to American industry and I'm sure this is welcome news indeed to those of you who could use new tools. It goes on to say in this abstract that this smelly air has been with us since the Greeks invented the word 'pneumaticos' and it has taken some 4,112 years to develop the de-P filter to do something about it.

These filters, one of them the Model L.S. (Little Snort) having a capacity ranging from zero to 71,210.22 Std. CFM and the other, the Model B.W. (Big Whiff) having a range from 71,210.78 to 313,162.56 Std. CFM, will cover all air requirements —in a steel mill, for instance, from the lowly researcher in his secret lab trying to de-P air at the rate of one bubble per minute to the ravenous appetite of the blast furnace.

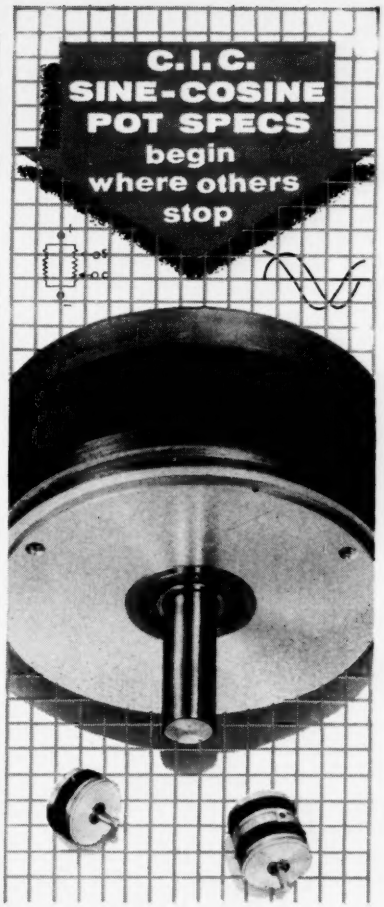
Usually plant air comes under the direction of the mechanical department, at the head of which is the master mechanic or master maniac as he is sometimes called. As this fellow is usually an elderly man suffering from corns, ulcers and acute biliousness who is short-tempered with your plaintive plea that "There must be something wrong with your air compressors; look at all the oil and crap that comes out of the air lines." it goes without saying that this filter will remove dirt, oil, water, gum boots, shoes, tin cans, bottles and other common diluents of plant air—and by throwing the easily available control knob from 'Minus' to 'Plus' this filter will also add dirt, oil, water, gum boots, shoes, tin cans, bottles and other common diluents to plant air, if you so desire. No other filter can make this claim!

The best part about this filter is that after conditioning the air to your heart's desire, another handy knob is right there to be pushed and one of several exciting scents is added to the air stream for best operation of the equipment. Among the scents available are those old favorites Evening in Paris and Chanel Number Five. Other popular scents are Two Nights in McKeesport, Chanel Two, Chanel Three and Chanel Seven, although the last one doesn't always come in good. Dr. Alles is presently analyzing all processes with the idea of determining the optimum scent level for minimizing losses. He has found, for instance, that blast furnaces do real well on the odor of men's locker room at 6 PM, wind tunnels thrive on the tangy odor of old sneakers, and one line of instruments won't do anything extra unless they are fed a diet of corned-beef and cabbage odor. (This is most peculiar because from the prices asked for the instrument one would suspect an appetite for caviar or something equally expensive.)

There isn't much required in the way of maintenance. The brochure says "No Maintenance is Necessary" (we don't believe everything we read, do we?)—other than connecting up the filter to your air lines and then, depending on what you want to add to your air, either a tank car of scent or a barge (if your plant is on the inland waterways) or a truck load of dirt, oil, water, gum boots, shoes, tin cans, bottles or whatever you wish to add is connected to the handy filler cap and you are in business.

For further information on this and other products circle number 7854 on the inquiry card.

Panhandle Pete



Infinite resolution and absolute dependability distinguish CIC ultra-precise Potentiometers. In the generation of the sine wave CIC Pots provide smooth, reliable performance, distortion free at all angles of rotation.

CIC carbon film Sine-Cosine Pots, the proven product of a unique research program, provide greater accuracy in smaller case sizes. Sizes range from 1" to 5" diameter with corresponding best conformities from .3% to .03%. Compensation for loading can be provided with **no loss of performance.**

At speeds in excess of 1,000 r.p.m. CIC guarantees life in excess of two million revolutions.

Many firms with critical specifications for industrial instrumentation, military fire control and flight guidance equipment rely only on CIC Potentiometers.

Our highly qualified engineers are ready to discuss your specific requirements with you. Call us today.

"For Precision Performance ... specify CIC"

Detailed Technical Data Sheets available on request.

CIC COMPUTER INSTRUMENTS CORPORATION
IVanhoe 3 8200
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For more information circle **16** on inquiry card.

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You, personally, are "right next door" to an alert source of supply of Fisher control valves, gas regulators, liquid level controllers and pressure regulators.

Whether your problem is one of existing equipment—or an entirely new control application—the Fisher country-wide network of 3 factories, 22 strategically located field stocks and 53 representatives, with 203 Fisher Service Engineers—offers you convenient service on all your control requirements.

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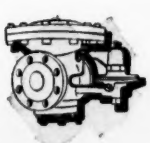
PRESSURE REGULATORS

GAS REGULATORS

LIQUID LEVEL CONTROLLERS

DIAPHRAGM CONTROL VALVES

PUMP GOVERNORS

LEVER AND FLOAT VALVES

INSTRUMENTS and AUTOMATION News

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Conference on Instrumentation for the Iron and Steel Industry

PITTSBURGH, PA.—The Seventh Annual Conference on Instrumentation for the Iron and Steel Industry will be held by the Pittsburgh Section ISA, March 26 and 27 with 16 papers to be read. The subjects of the four sessions will be "General Steel Mill Instrumentation," "Instrumentation for Blast Furnace," "Automation for Strip Steel Processing," and "Controls for Modern Steel Melting." The interest shown in this event promises to set a new record in attendance figures, which previously topped 200 by a wide margin.

New RETMA Standards

New York, N. Y.—Six new standards have been recommmended by RETMA. They are:

RS-171—High Voltage Ceramic Dielectric Capacitors, Class 2 (This Standard, from Standards Proposal No. 445, is new material)

RS-172—Fixed Composition Resistors (This Standard, from Standards Proposal No. 493, is a revision of REC-116)

RS-173—Emergency stand-by Power Generators and Accessories for Microwave Systems (This Standard, from Standards Proposal No. 504, is new material)

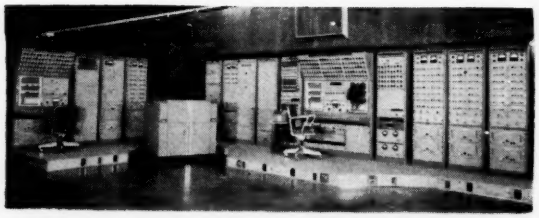
RS-174—Audio Transformers for Electronic Equipment (This Standard, from Standards Proposal No. 512, is a revision of TR-121)

RS-175—Audio Inductors (This Standard, from Standards Proposal No. 513, is a revision of TR-122)

RS-176—Pulse Transformers for Radar Equipment (This Standard, from Standards Proposal No. 515, is a revision of TR-129)

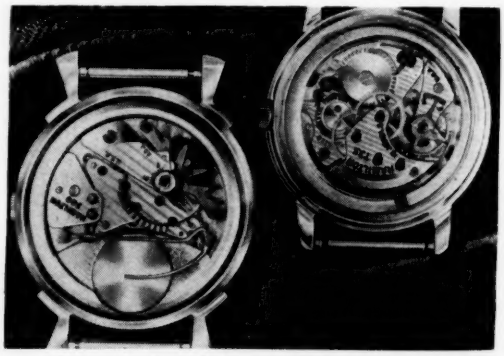
European Analog Computation Center

LONG BRANCH, N. J.—Brussels, the Belgian capital, has been picked by Electronic Associates for the first European computation center similar to the ones operated by the company in Princeton and Los Angeles. Several PACE (Precision Analog Computing Equipment) systems have been sold in Europe, notably in Sweden, France, and Italy, a fact which has prompted the company's decision for establishment of a center on the European continent. It will be staffed by European scientists, while specialized personnel from the United States will complement the staff as required. Brussels was selected because of its central location, excellent transportation facilities, stable and convertible Belgian currency, and cooperative attitude. It is hoped that this computation center will accelerate European interest in analog computers.



World's First Electric Wrist Watch

LANCASTER, PA.—Called the "first basic change in portable timekeeping in 477 years" the electric wrist watch, a development of the Hamilton Watch Company, offers the highest accuracy and dependability ever achieved. It operates on chemical energy stored in a tiny gold-plated "Energizer," which was developed in close cooperation with the National Carbon Co. This energy is converted into electric power by releasing a stream of electrons through a coil of fine wire fixed on a balance wheel. The electric energy interacts with a permanent magnetic field to cause the balance wheel to oscillate. This oscillation is the mechanical energy which runs the watch. The power plant, combined with a balance wheel, permits the flow of energy to be strictly controlled; speed of the hands is held to an accuracy of more than 99.995%. The tiny magnets used in the electrical system are of platinum alloy and have the highest energy content of any magnet in the world today.



The first model, cased in 14 karat gold, no larger than a conventional wrist watch, retails for $175.00; a gold-filled model will cost less than $90.00.

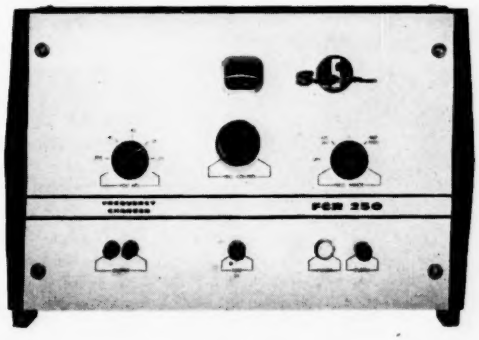
NOW-PORTABLE
400 cycle power

This new frequency changer makes it possible to provide well regulated 400 cycle power conveniently and quickly. This unit, Model FCR 250, is extremely useful in a wide variety of applications including testing, production, airborne frequency control, computers, missile guidance system testing, and in practically any application where the use of 400 cycle power is advantageous.

Model FCR 250 is only one of a complete line of frequency changers available from Sorensen . . . the authority on controlled power for research and industry. Write for complete information.

ELECTRICAL CHARACTERISTICS

Input	105-125 VAC, 1 phase, 50-65 cycles
Output voltage	115 VAC, adjustable 105-125V
Output Frequency	320-1000 cps in two ranges
Voltage regulation	±1%
Frequency regulation	±1% (±0.01% with auxiliary frequency standard fixed at 400 cycles)
Load range	0-250 VA



MODEL FCR 250

SORENSEN & COMPANY, INC. Sorensen **STAMFORD • CONN.**

In Europe, contact Sorensen-Ardag, Eichstrasse 22, Zurich, Switzerland, for all products including 50 cycle, 220 volt equipment.

For more information circle **18** on inquiry card.

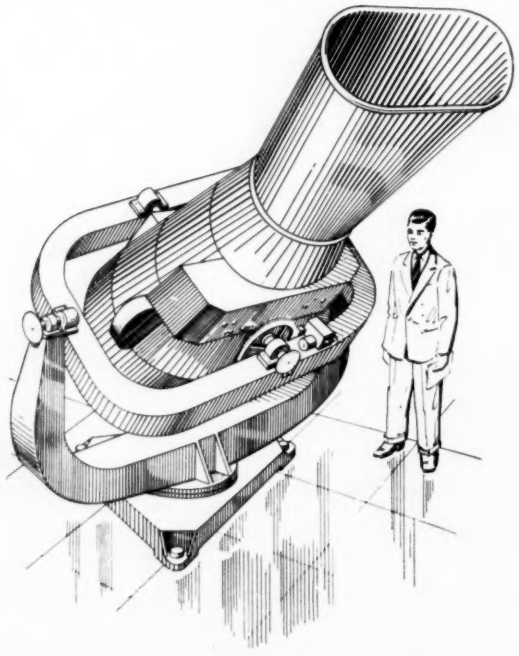
Printed-Circuit Forum

CINCINNATI, OHIO—The Formica Company held a Printed-Circuit Forum recently at which 300 representatives of the electronics industry gathered to discuss technology and future of the new field of printed-circuits. Printing, etching, electroplating, component insertion, and soldering of printed-circuits were reviewed by nine speakers. Highlights of the program were: *Printing of Acid Resist, Wet Silk Screen Method,* John P. Shaffer, Cudner and O'Connor Company; *Printing of Acid Resist, Photo-Sensitive Method,* W. P. Van Deusen, Eastman Kodak Company; *Etching Techniques and Methods,* St. John Bain, Formica Corporation; *Dip Soldering Operation,* Clifford L. Barber, Kester Solder Company; *Electroplating of Printed Circuits,* Robert Swiggett, Photo Circuits Corporation; *Automatic Assembly of Component Parts,* Richard W. Daniels, United Shoe Machinery Corporation; *Printing of Acid Resist, Dry Silk Screen Method,* James H. Reed, Dry Screen Process, Inc.; *Punching and Machining Techniques,* George E. Power, Formica Corporation; *Printed Circuits—The Key to the Future,* Jack Cochrane, Formica Corporation.

Satellite Tracking

NORWALK, CONN.—Twelve special cameras, with one of the most difficult-to-produce optical systems ever attempted, will soon go into production for the task of photographing the IGY earth satellite, an object the size of a basketball travelling at twice the speed of sound.

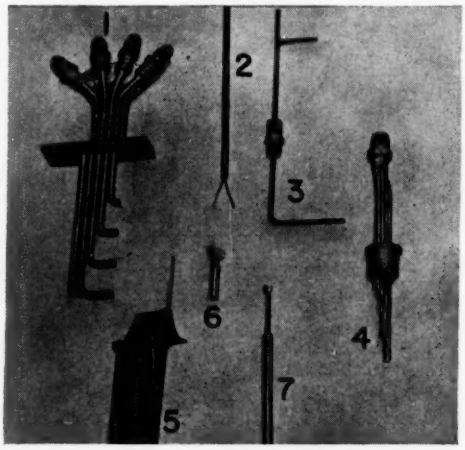
The twelve IGY Satellite Tracking Cameras, strategically placed about the globe, will be used for the optical tracking of the satellites in conjunction with radio listening stations, astronomical observatories and amateur observations (the latter dubbed "Operation Moonwatch"). Two of the cameras will be stationed in the United States.



The production of the optical systems for the cameras is being undertaken by the Perkin-Elmer Corp. The cameras with 20-inch aperture, and ultrafast f/1.0 apochromatic lens, have a 30° field of view.

Shortcut in TC Production

NORRISTOWN, PA.—Thermocouples made by Marlin Manufacturing Co. have two thermocouple wires inside a ceramic insulator which has been crushed to powder form and packed tightly by swaging a sheath made from metal tubing. Usually, they are inserted



through drilled holes in test engines, gas turbines, heat treating furnaces and chemical and processing equipment to measure internal temperatures. A close fit is required to minimize heat loss or to fit standard tube fittings to facilitate installation.

Fabrication has been simplified by using metal tubing which is swaged. The swaging compresses the metal tubing in which the thermocouple wires are inserted, and crushes the ceramic, packing it to hold the wires in place.

To meet the varying specifications, tubing is needed in four stainless analyses and in Inconel. Drawn to slightly larger dimensions than standard tube fitting sizes, tubing supplied by Superior Tube Company fulfilled the requirements and simplified production.

Illustration shows the insulated thermocouple (2) protected with a sheath. Other uses of tubing in pickups are also shown, including a pressure rake (1), pitot static tube (3), thermocouple rake (4), instrumented turbine blade (5), shielded pressure probe (6), and flow probe for sensing direction of flow of gases or liquids (7).

Mobile Laboratory

CHICAGO, ILL.—A complete Mobile Testing Laboratory was completed recently by Soiltest, Inc., for the Bureau of Public Roads. It is fully equipped for standard soil and concrete tests and will be used on the Bureau's overseas road planning and construction projects.

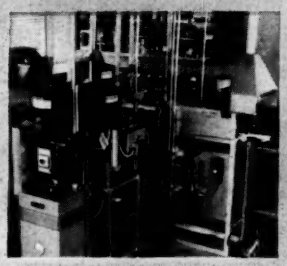
The mobile unit is designed to be self sufficient. It carries its own water supply, laboratory sinks, air compressor, air conditioner, vacuum pump and similar utility equipment. Test equipment includes a portable

another basic reason why industry prefers

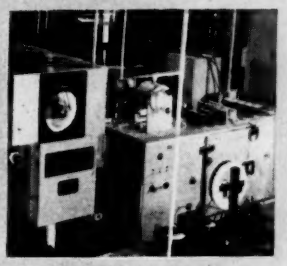
OHMITE®
COMPONENTS

better quality through more advanced research and testing!

Behind every Ohmite component is a bulwark of *advanced* research and testing laboratories. These laboratories use the finest scientific instruments and equipment. Here Ohmite products are tested and retested under the most grueling conditions to detect possible sources of trouble. And these same laboratories are used for the development of new materials, new processes, and new designs . . . to build *reliability* into Ohmite products that set new standards for long life and trouble-free performance.

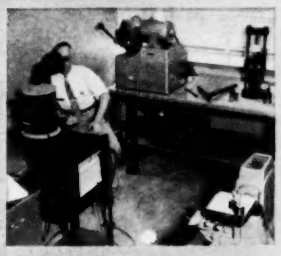


High temperature globar furnace; muffle furnace for enamel testing; hydrogen atmosphere sintering furnace.

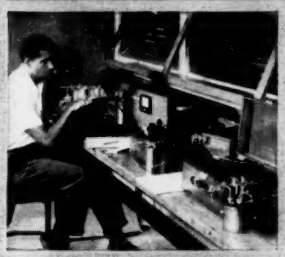


Humidity chambers using program-controlled cycles; here Ohmite products are tested under a wide range of temperature and humidity conditions.

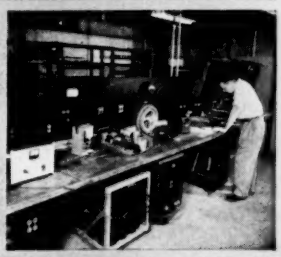
Microscopic and petrographic equipment used in Ohmite laboratories for optical examination of materials and products.



Microscopic analysis of structure using metallograph. Thermal expansion of ceramics and vitreous enamels can be determined with interferometer equipment.

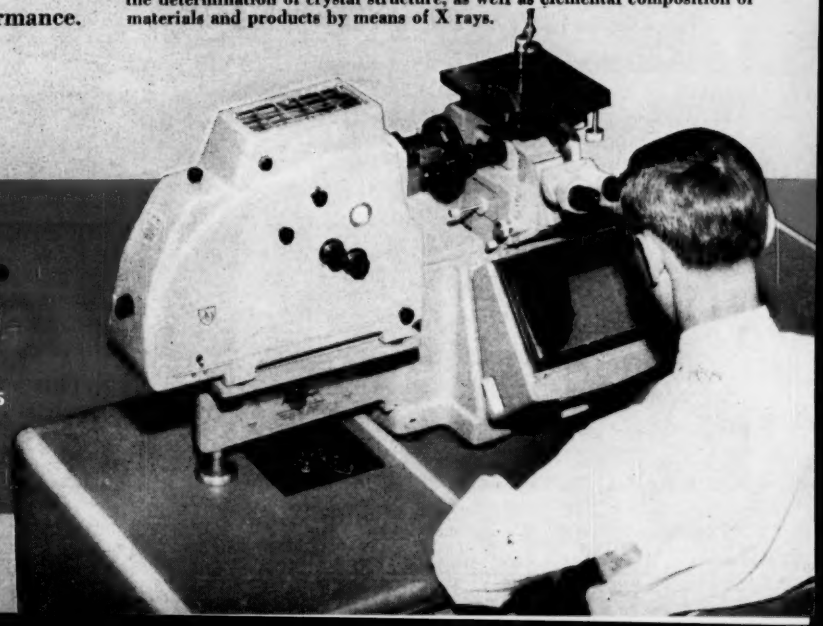


Instruments shown above are used to check and standardize the many pieces of Ohmite electrical test equipment.



This power panel provides AC or DC in a wide range of currents, voltages, and frequencies ...permits testing Ohmite products under operating conditions.

X-ray Diffractometer and X-ray Fluorescence Spectrometer make possible the determination of crystal structure, as well as elemental composition of materials and products by means of X rays.



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TAP SWITCHES • TANTALUM CAPACITORS

OHMITE MANUFACTURING CO.
3648 Howard Street, Skokie, Illinois

For more information circle 19 on inquiry card.

"BANTAM"

500 SERIES Miniature Throttling Diaphragm Control Valves

Because of the growing need for compactly designed, lightweight valves with the same ruggedness of construction and high quality found in standard dimensioned control valves, this new line of "Bantams" is offered.

The type 501 valve shown has ¼" N.P.T. connections, and for service up to 1000 psi at 350°F. will provide throttling control with low hysteresis and instantaneous response over a 3 to 15 psi instrument air range. It has five interchangeable sizes of linear, equal percentage, or quick opening trim. CV = 0.63 to 0.00025 trim sizes.

Types 526 and 530 valves are available in sizes from 1" to ¼" screwed, flanged, and weld ends, for service up to 1500 psi in A.S.A. Ratings. All materials and construction are consistent with usual control valve specifications.

Reversible integral seat and replaceable seat bodies are available as well as the usual control valve extras.

For a full description of the Bantam 500 series, drop us a line. We will be glad to put you in touch with our representative in your area.

George W. DAHL Company

BRISTOL, RHODE ISLAND

For more information circle **20** on inquiry card.

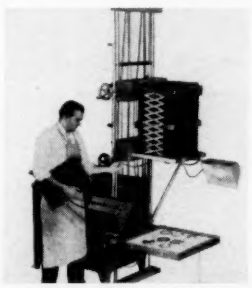
200,000-lb-capacity concrete testing machine for 6" by 12" cylinder tests. Soil testing apparatus ranges from permeameters to a field California Bearing Ratio set and unconfined compression testing machines.

News Bits

PANELLIT SERVICE CORP., a division of Panellit Inc., received a unique automation contract from Tidewater Oil Corp. providing for complete instrumentation-and-control-system maintenance in the company's giant new "Flying A" refinery in Delaware.

CARBIDE & CARBON CHEMICALS CO. announces availability of 3 instrument patents for licensing. The company itself is using all three instruments. They are: (1) A chromatographic analyzer for continuous, automatic analysis for one or more components in a mixed-gas stream, (2) a differential refractometer, and (3) an electrolytic concentration cell that measures the difference between the ionic concentration of two liquids. Carbide uses it for measuring ppm of oxygen in plant streams.

BURKE & JAMES are marketing a new versatile process camera which can be operated in a vertical position. It can be used for copying, enlarging and reducing, turning out negatives or positives including xerographic plates for printing up to 24" x 24".



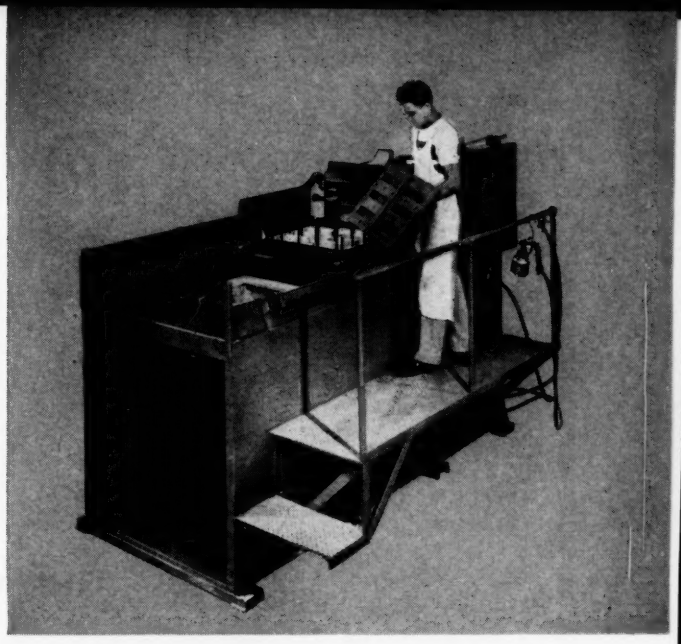
Burke & James Camera

Acoustica Soldering Iron

ACOUSTICA ASSOCIATES, representing Mullard in the U. S., introduced a new ultrasonic soldering iron which uses no flux for soldering aluminum and its alloys, copper, brass and zinc, as well as for joining of dissimilar metals. The intense ultrasonic vibrations communicated to the solder erode the oxygen skin.

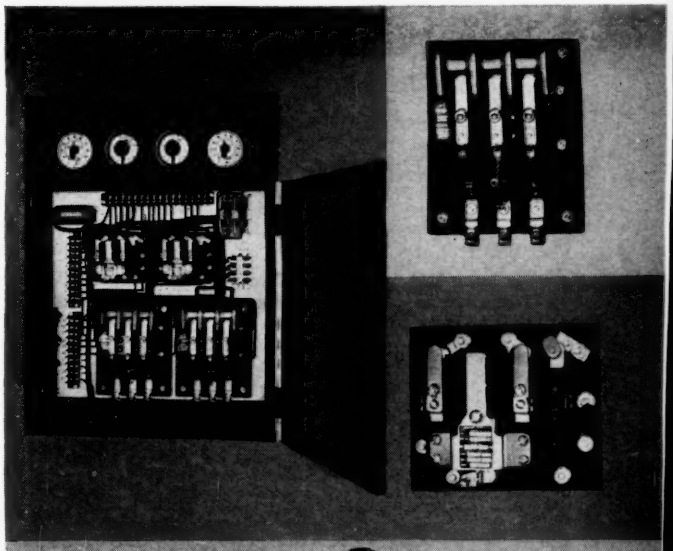
UNITED STATES RADIUM CORP. announces new commercial markers utilizing long-lived radioactive gas (Krypton ^{85}) to excite treated phosphor crystals. Signal lights in 5 different colors are easily legible at distances in excess of 500 yards.

50 precision shell molds per hour with ASCO CONTROLS



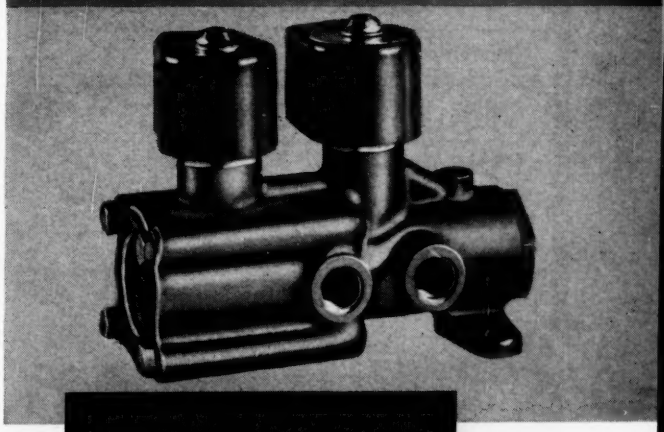
Dependable precision control by ASCO has been a long time feature of a wide range of automatic equipment and machine tools. A typical example is the Shell-O-Matic high speed shell molding machine shown here. The machine produces precision shell molds for casting in ferrous and non-ferrous metals. ASCO solenoid valves sequenced by ASCO relays completely control the operation.

Integrated in the control system are the ASCO control panel, single and dual solenoid valves with watertight molded coils, relays and contactors. These controls help Shell-O-Matic achieve a production rate of 50 precision units per hour.



ASCO CONTROL PANEL

This control panel consists basically of two ASCO 1054 Relays and 1035 Contactors. The 1054 is especially designed for rugged industrial use with powerful efficient magnet for positive action. It is a 25 ampere relay, available in a variety of pole combinations up to 12 poles. The Bulletin 1035 is a continuous duty contactor, suitable for all classes of load, with interrupting capacity of 6 times rated current. Standard ratings are to 300 amperes; contactors with higher capacities are available.



ASCO SOLENOID VALVES

ASCO Bulletin 8344 4-way solenoid valves are especially designed for double acting pneumatic or hydraulic cylinders. In this installation watertight luxolene molded coils have been specified since the shell molders are washed down frequently. These poppet type valves provide tight seating with absolutely no leakage. They are power driven in both directions by line pressure. A full line is available: sizes ⅜"– 1" with single or dual solenoids and J.I.C. construction.

These quality products are representative of the complete line of ASCO controls now available. Design *your* control system with ASCO electromagnetic control and solenoid valves. Technical literature and engineering assistance are available. Write ASCO today about your control problem.

Automatic Switch Co.

52-F Hanover Road, Florham Park, New Jersey

For more information circle **11** on inquiry card.

ASCO®

REMOTE BULB, INDICATING TEMPERATURE CONTROL E32N

Featuring Control Point Accuracy Equivalent to Individually Calibrated Instruments

The **UNITED ELECTRIC** Type E32N Temperature Control is a uniquely designed instrument that is used to control and indicate temperatures of gases, liquids or hot plates over wide ranges. This unit contains a 12-inch scale for easily read visual indications. It is possible to replace the thermal unit in the field without any loss of calibration accuracy.

Temperature Ranges	—150°F. to 150°F., 70°F. to 370°F., 100°F. to 650°F. Read temperature on continuous, 12-inch indicating scale that rotates against a fixed index pointer in a vertical and centered location.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment	Calibrated dial rotated against a fixed index.
Calibration	Calibrating mechanism permits precise matching of scale to individual tolerance errors of thermal assemblies.
Compensation	Automatic compensation for ambient temperatures.

SEND FOR NEW Catalog 200 for full information on the E32N and other remote bulb temperature controls.

U.E.I.®

United Electric Controls
COMPANY
81 SCHOOL STREET WATERTOWN, MASS.

For more information circle **22** on inquiry card.

NEWS —CONTINUED

NATIONAL ENGINEER'S WEEK will be observed February 17 through 23. Sponsored by the National Society of Professional Engineers, the theme for the 1957 observance is "Engineering . . . America's Great Resource." Said Mr. John L. Bahr, National Committee Chairman: "This theme was chosen because of the increasing public awareness of the fact that the real resources of this country are not buried in the crust of the earth, but are actually walking around several feet above ground . . . in the minds and attitudes of our professional engineers."

CORNELL AERONAUTICAL LAB. has resumed test operations of its 32,000-hp wind tunnel after a modification program that cost nearly $2¼ million. Tests with aircraft, missiles, and propellers at speeds 1.3 times the speed of sound at varying pressures now can be computed and recorded automatically, providing test data for evaluation minutes after completion of measurements.

BECKMAN INSTRUMENTS' SPINCO DIV. will manufacture a powerful new ultraviolet sterilizer which scientists at Michael Reese Research Foundation of Chicago invented. Production of completely safe vaccines for immunization against polio and a variety of other diseases from rabies to arthritis are predicted with its aid.

PROJECT-VANGUARD NEWS

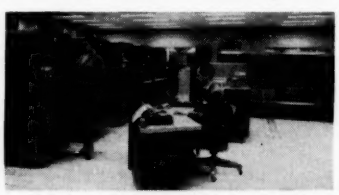
- An **IBM** 704 Computer will be installed in Washington for evaluating data obtained from radio tracking stations and observation points located in various parts of the world. The orbit of the earth satellite can be plotted on the screen of the Cathode Ray Tube Output Recorder (CRT) as the information is computed by the machine.

- **UNIVERSAL ATOMICS CORP.** has developed a transistorized all-electronic power supply that will be used in the earth satellite.

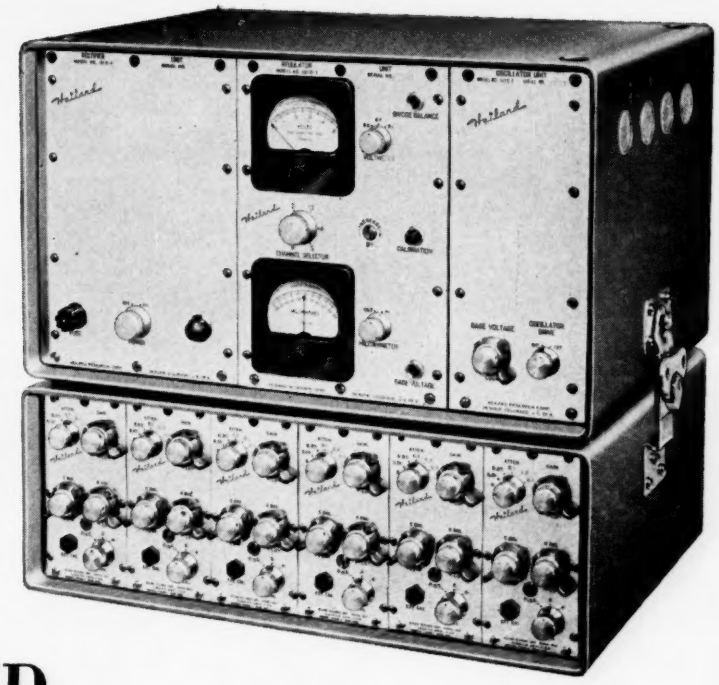
NEW COMPUTER DEVELOPMENTS

- **STANDARD OIL CO. OF INDIANA** was the recipient of the one hundredth IBM computer in the 700 series. This "705" is the largest and fastest computer produced by IBM for handling commercial problems. It will facilitate operation of the Whiting Refinery in many ways, tackling payroll, job order cost system, computation of petroleum inventories and refinery, yields, etc.

Indiana's IBM "705" ▶



- **REMINGTON RAND'S** first Univac Scientific 1103A, recently installed at Lockheed's Missile Systems Division, has been equipped with two important programming shortcuts by its mathematicians, unglamourously dubbed MISHAP (missiles high speed assembly program) and FAP (flating arithmetic package). They will on one hand permit feeding 24 alphabetic and decimal characters instead of binary language, and on the other hand



Carrier Amplifier Units for:
Resistive transducers
Linear differential transformer pickups
Variable reluctance gages

Linear-Integrating Amplifiers for:
Self-generating transducers.

The HEILAND 119 Amplifier System for Oscillographic Recording

All these features—plus many more—have moved Heiland 119 Amplifier Systems into leadership in the field!

All operating controls are on the front panel; all cabling is on the back panel for handy relay rack or test bench mounting without modification.

The 119 System is flexible to meet present or future needs, since all 6 individual amplifier units within the system are easily removable. You can build your system from the ground up, adding new individual units as your need expands.

In addition, linear-integrate and carrier units are interchangeable within the system case.

COMPARE THESE FEATURES with similar systems:

- **TWICE THE SENSITIVITY**
  ½ millivolt for full current output
- **TWO-THIRDS GREATER FREQUENCY RESPONSE**
  0 to 1000 c.p.s.
- **TEN TIMES THE CURRENT OUTPUT**
  50 ma into 20-ohm load
- **EXCELLENT STABILITY**
  less than 2% variation with line voltage fluctuation and wide range of ambient temperatures

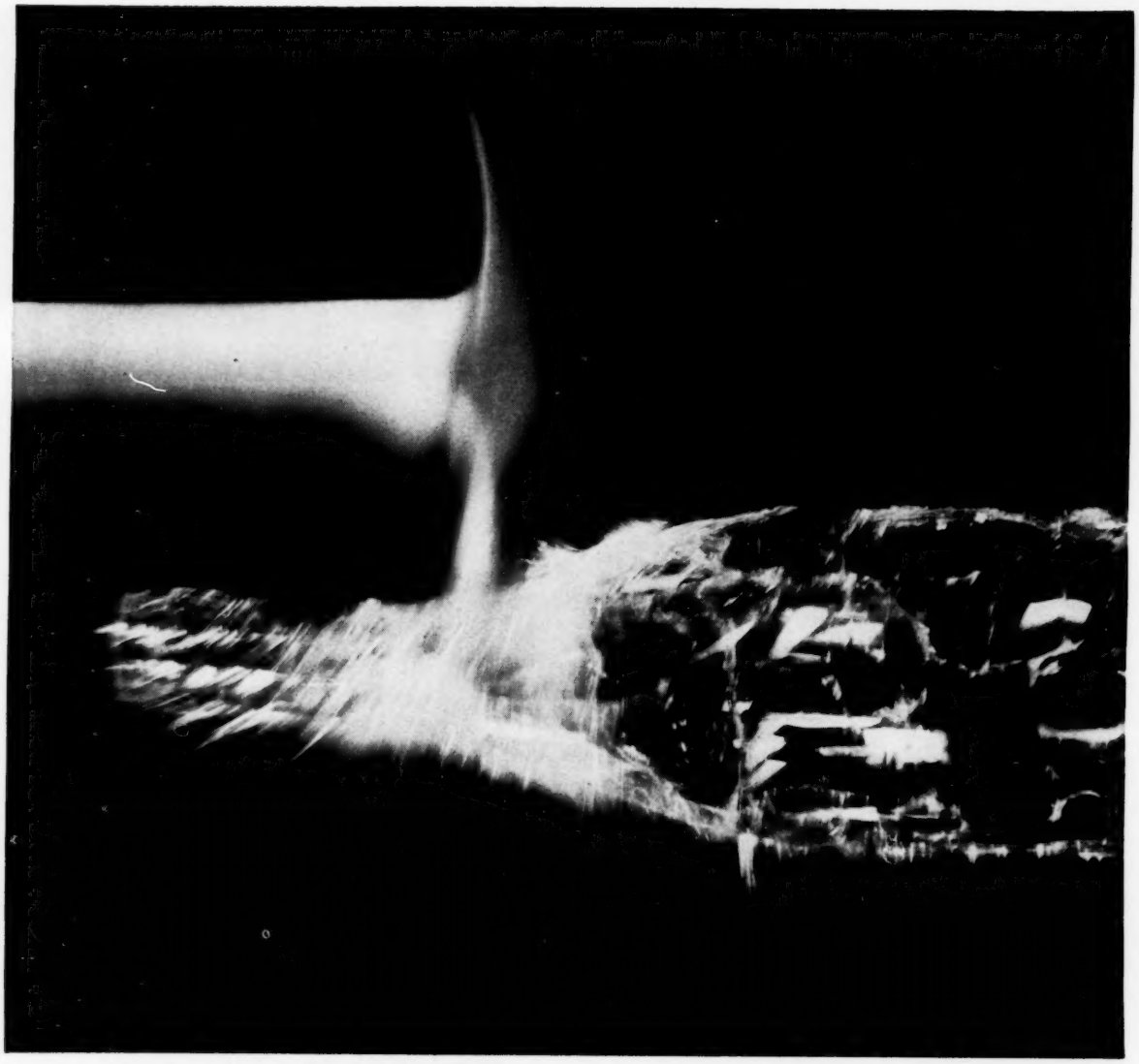
FOR ADDITIONAL DETAILS WRITE FOR BULLETIN 101-NA
FOR PERFORMANCE AND CONVENIENCE—CHOOSE THE HEILAND 119 AMPLIFIER SYSTEM.

MINNEAPOLIS **Honeywell**

HEILAND INSTRUMENTS

5200 EAST EVANS AVENUE • DENVER 22, COLORADO

For more information circle **23** on inquiry card.



IMPACT

It takes the impact of specialized engineering to break bottle-necks that block the practical application of automatic control, data handling and other system problems in both the civilian and military fields.

DAYSTROM SYSTEMS DIVISION takes full responsibility for the conception, design, assembly, testing and installation of complete systems, including the training of user personnel.

DAYSTROM SYSTEMS engineers are qualified to integrate and apply to systems problems, equipment from the electronic, electrical, optical, hydraulic, pneumatic, mechanical and other fields. Whenever DAYSTROM or other existing equipment does not meet optimum system specifications, the DIVISION will design and manufacture special components. Full advantage will be taken of the extensive experience of the entire DAYSTROM organization with servo-mechanisms, controllers, aircraft systems, computer and memory devices, gyroscopes, telemetering equipment and digital systems.

A DAYSTROM designed system is the key to more efficient, more profitable operations. For further information, call or write for our FACILITIES REPORT. See us at the I·R·E Show in New York, March 18-21, Booth 2907-15.

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DIVISION OF DAYSTROM, INC.
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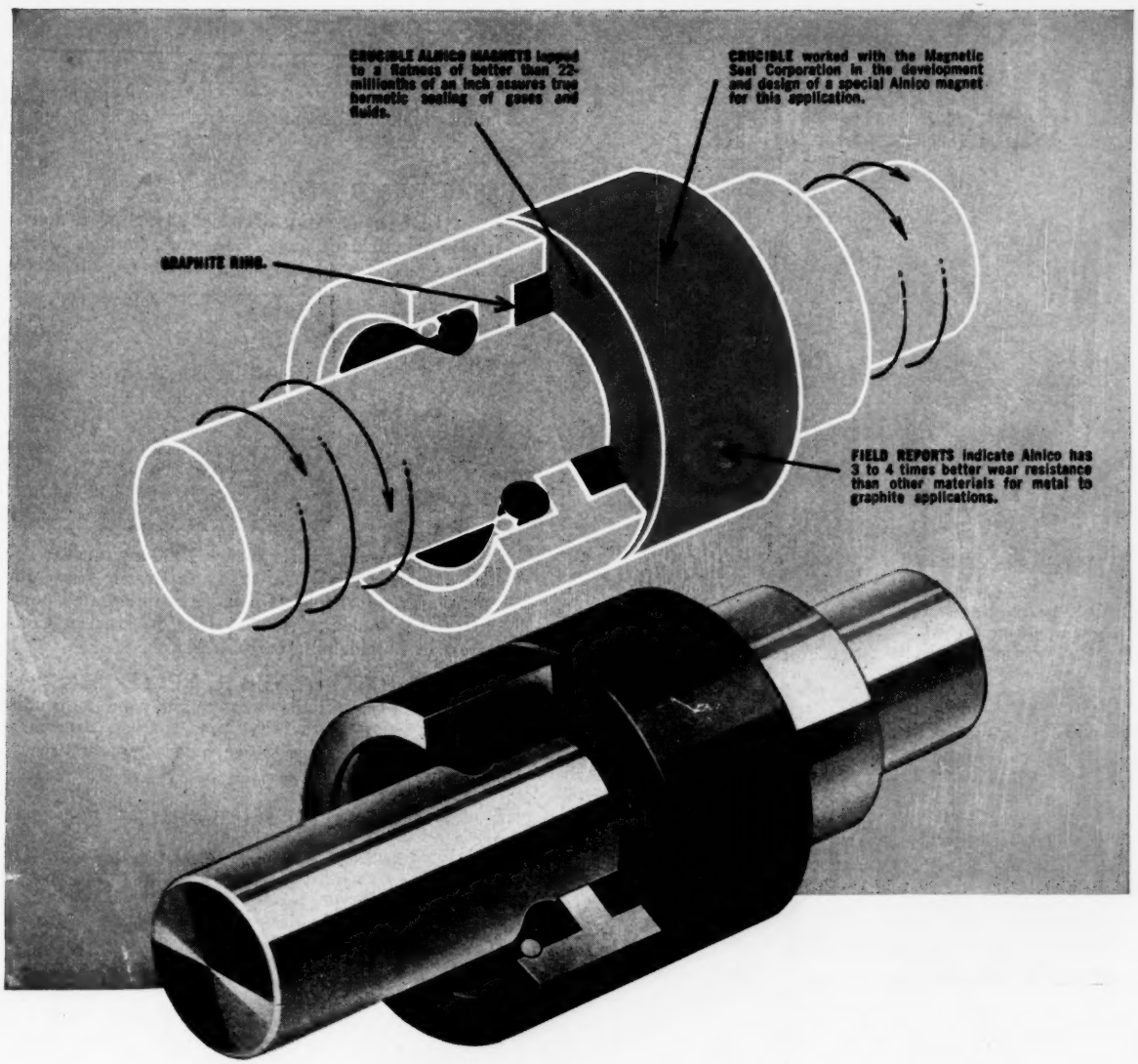
LA JOLLA, CALIFORNIA
GLENCOURT 4-0421

For more information circle **24** on inquiry card.


CRUCIBLE ALNICO MAGNETS lapped to a flatness of better than 22-millionths of an inch assures true hermetic sealing of gases and fluids.
CRUCIBLE worked with the Magnetic Seal Corporation in the development and design of a special Alnico magnet for this application.
GRAPHITE RING.
FIELD REPORTS indicate Alnico has 3 to 4 times better wear resistance than other materials for metal to graphite applications.

in magnetic seals, too

CRUCIBLE PERMANENT MAGNETS

mean maximum energy—minimum size

The consistently higher energy product of Crucible Alnico magnets allows smaller parts – greater compactness in special applications like this magnetic shaft seal. What's more, the superior corrosion and wear resistance of Crucible Alnico insures far greater service life.

You can regularly get Crucible permanent Alnico magnets sand cast, shell molded, or investment cast to exact size, shape or tolerance requirements . . . and in any size from a mere fraction of an ounce to hundreds of pounds. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

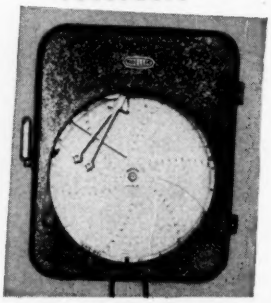
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

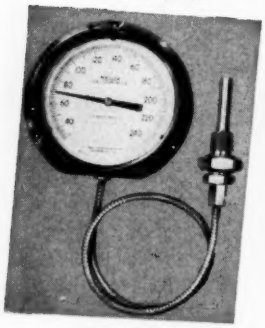
For more information circle **25** on inquiry card.

You get dependability PLUS with Moeller dials and recorders

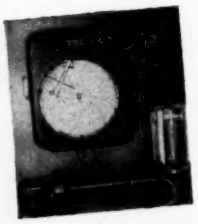
Adjustable Form Dial Indicating Thermometers with separable socket. Can be quickly adjusted to any angle.



Single and Multiple Pen, Remote Recording Thermometers. Available for one and two temperature recordings in round cases and up to four temperature recordings in rectangular cases.



Remote Reading Dial Thermometers. Mercury actuated, with separable socket. Panel or flush mounting.



Moeller Recording Psychrometer Type No. 6630 (wet and dry bulb temperature type) for accurate humidity determinations and records. Designed for rooms or apparatus where air circulation is poor.

...because our business is the design and manufacture of temperature measuring instruments—and has been since 1867.

Specify and install these guaranteed Moeller Products. *Mail the coupon, today, for full details!*

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Dials and Recorders.

NAME .....

FIRM .....

ADDRESS .....

CITY..... ZONE..... STATE.....

For more information circle **26** on inquiry card.

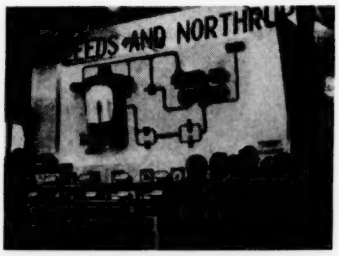
NEWS —CONTINUED

allow input and output on punched cards or magnetic tape.

NUCLEAR REACTORS

• **LEEDS & NORTHRUP CO.'S** great activity in the field of nuclear reactors controls is reflected in news of having received a contract to

L&N Nuclear Display ▶



supply a "package" for a new 1000-kw nuclear reactor at Sao Paulo University in Brazil. The company also will display a completely integrated power reactor control system at the 1957 Nuclear Congress in Philadelphia early in March.

• **AEROJET-GENERAL NUCLEONICS** will exhibit an operating reactor at the coming Atomic Exposition. It is the first time that an American audience will be able to see such demonstration.

Stock Report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

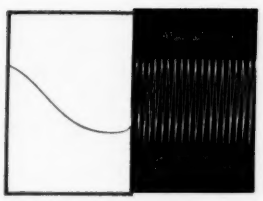
New York Stock Exchange:

SECURITY	Price Range for 1956-57 Thru Jan. 18 HIGH	LOW	AS OF JAN. 18, 1957
ACF Industries	67 7/8	55	61¼
Aeroquip Corp.	22 5/8	11 7/8	20 3/4
Allis Chalmers	37½	30 1/8	33 7/8
American Chain & Cable	61 3/8	36½	54½
American Machine & Foundry	40 3/4	24 1/8	34 7/8
American Machine & Metals	45 3/4	35 1/8	42 1/8
American Optical	40 3/4	33 1/8	33½
American Telephone & Telegraph	187 1/8	165	174 7/8
Beckman Instruments	43 1/8	25 1/8	38 3/8
Bell & Howell	50 7/8	28¼	48
Bendix Aviation	64 3/8	40½	59 3/4
Boeing Airplane	69 3/8	45 3/8	57½
Bullard	38 3/8	26	27½
Bulova Watch	23	20 1/8	20 5/8
Burroughs	46 7/8	28½	37½
Carborundum	45 5/8	31½	41½
Cincinnati Milling Machine	55¼	37¼	40
Clevite	24¼	18	19½
Columbia Broadcasting "A"	34½	22 5/8	31
Consolidated Electronics	36½	26½	32 3/4
Cornell Dubilier	40 1/8	23	25 7/8
Corning Glass	87½	60¼	62½
Curtiss-Wright	49 3/4	26 3/4	45¼
Cutler Hammer	65	53	61
Daystrom	32½	22	30½
Dobeckmun	39¼	25½	25½
Douglas Aircraft	95 5/8	72½	86 3/4
Eastman Kodak	100 3/4	75 3/4	86 3/4
Eaton Manufacturing	66	51½	62 3/4
Electric Auto Lite	41 3/8	32 1/8	32 1/8
Elgin Watch	17 3/8	11	13½
Food Machinery & Chemical	77	51	57
Gamewell	36½	25 5/8	33
Garrett	54½	38	53½
General Dynamics	59 5/8	45 1/8	56¼
General Electric	65½	52 3/4	54 3/4
General Instrument	10 1/8	6 3/8	7 1/8
General Mills	71 3/4	61	64½
General Precision Equipment	53½	34½	42
General Railway Signal	34	29	30½
General Telephone	46	38	40¼
General Time	34 5/8	29½	29½
General Tire	66 3/4	47¼	61½
Goodyear	84	60	76 3/8
Hamilton Watch	28½	19	27
Hoffman Electronics	25 3/8	18½	18½

Continued on page **214**

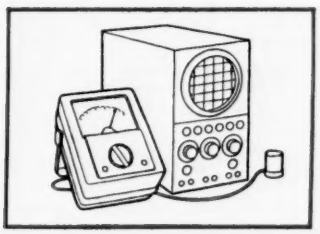
Most convenient vibration meter available today

PORTABLE



FREQUENCY RANGE OF 10 TO 1000 CPS

TYPE 1-128



VERSATILE

You can carry this compact instrument *anywhere* for vibration analysis in either shop, field, or mobile applications. An *all-transistor, etched-circuit* design, the 1-128 Vibration Meter is battery-powered... weighs only 7½ lbs.

SELF-CONTAINED...With the addition of a linear or torsional vibration pickup, the convenient 1-128 becomes a completely self-contained monitoring system. Peak-to-peak displacements as small as 0.0005" cause full-scale indication. Vibration displacements are accurately measured in the frequency range of 10 to 1000 cycles.

VERSATILE...An oscilloscope can be coupled to the meter through an output jack for visual waveform analysis. Simple to operate and designed to meet adverse environmental conditions, your CEC 1-128 will pay for itself many times over.

SAVES THOUSANDS OF DOLLARS...A large Los Angeles refinery is using the Consolidated 1-128 Vibration Meter to monitor bearing vibration on sealed motor-driven pump units. With a vibration pickup, the instrument provides a convenient, highly dependable vibration monitoring system in this hazardous location... saves thousands of dollars in preventative maintenance.

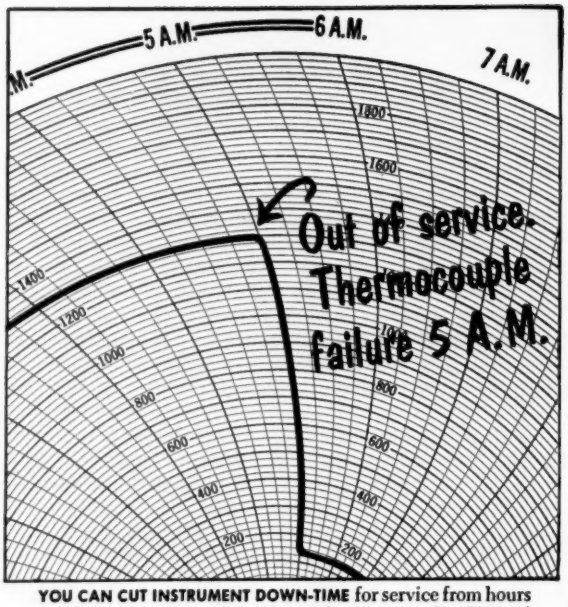
For complete specifications, please write for Bulletin CEC 1566-X30, or contact your nearby CEC field office.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

NATIONWIDE COMPANY-OWNED SALES & SERVICE OFFICES

For more information circle **27** on inquiry card.



YOU CAN CUT INSTRUMENT DOWN-TIME for service from hours to minutes in most cases with an adequate supply of Bristol thermocouples and pyrometer accessories.

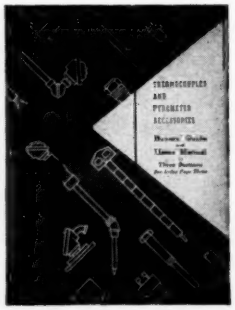
How much can interrupted pyrometer service cost you?

Now's the time to worry—before it happens—about what interrupted pyrometer service can do to your production schedules, cost figures, and quality controls.

And now's the time to lay in a supply of Bristol's pyrometer supplies and accessories to cut down-time to a minimum. Bristol's complete line of thermocouples, protection tubes, radiation-unit accessories, refractory insulators, mounting fixtures, thermocouple wire, and extension wire, switches, ink, and charts, are available in a wide selection of interchangeable sizes and types to fit all standard installations.

They're backed by Bristol's 51 years experience in industrial pyrometry. We've built thousands of pyrometers for every application—in iron, steel, non-ferrous metal smelting and refining; in petroleum, chemical, ceramics, glass, paper, and food-processing industries and in power, heat and incineration utilities.

You'll find these pyrometer supplies completely described in our 56-page Bulletin P1238, together with technical data on selection, installation, maintenance, and calibration. Write for your copy today. The Bristol Company, 154 Bristol Rd., Waterbury 20, Conn.



FREE BULLETIN P1238. Tells how to select, install, calibrate and care for thermocouples and pyrometer accessories.

BRISTOL *Points the Way in Human-Engineered Instrumentation*

6.18

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **28** on inquiry card.

New York Stock Exchange:

Continued from page 212

International Business Machine	550	400	515
International Tel. & Tel.	37 3/8	29½	29 7/8
Lockheed Aircraft	58 7/8	43½	53 3/8
Magnavox	41	31½	36½
Minneapolis Honeywell	90½	58	78½
Minnesota Mining & Mfg.	75½	60½	60½
Motorola	51 3/4	37½	37½
National Acme	82	62	75½
National Cash Register	59	34 1/8	51
North American Aviation	49 7/8	34½	34 3/4
Northrop	29 1/8	21½	25
Otis Elevator	50 3/4	33½	43 3/4
Philco	36½	16	16 5/8
Radio Corp. of America	50 3/8	31 3/4	31 7/8
Raytheon	20 7/8	13	18 7/8
Rheem Manufacturing	37 1/8	17 3/8	19 7/8
Robertshaw Fulton	28 5/8	21½	27 3/4
Sangamo Electric	37½	29½	33½
Sperry Rand	29 1/8	21 3/4	22
Square D	31½	22 5/8	30
Standard Coil	12 3/4	6½	8½
Starrett, L. S.	73 3/4	43 3/4	68
Stewart-Warner	39½	30½	33 7/8
Sylvania Electric	55 7/8	41 3/8	41½
Telautograph	15½	6 3/8	7½
Texas Instruments	18 3/8	11 5/8	17½
Thompson Products	80	48 3/8	71
Tung-Sol Electric	36 3/8	27	29
Underwood Corp.	44	20 7/8	25 7/8
Union Carbide & Carbon	133 3/8	103½	109½
Western Union	22½	17½	19 1/8
Westinghouse Air Brake	36 3/8	26 5/8	29 5/8
Westinghouse Electric	65 7/8	50 7/8	54 3/8
Worthington Corp.	60½	41 1/8	55½

American Stock Exchange:

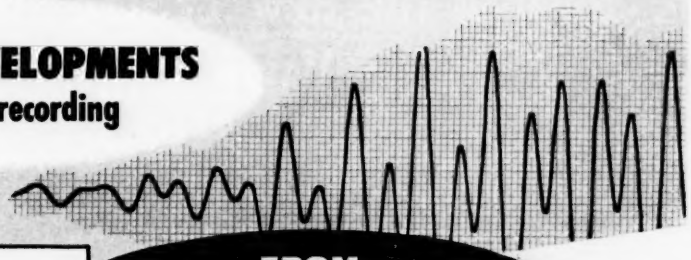
Price Range for 1956-7
January 18

SECURITY	HIGH	LOW	AS OF JAN. 18, 1957
Air Associates	13½	9	10-11 (1)
American Meter	41	31½	32½-33 (1)
Arc Equipment	2¼	17½	19 1/8
Belock Instrument	19 3/8	12½	12½
Benrus Watch	10 3/8	7	7½-7 3/4 (1)
Breeze Corp.	9 1/8	5 7/8	7
Clark Controlbr	37	16½	26½-29½ (1)
Clarostat Mfg.	5	3 1/8	4-4½ (1)
Clary Corp.	6 7/8	4½	4 3/4
Consolidated Electrodynamics	40	21	34 3/4
Du Mont Laboratories	10	4 3/8	5½
Dynamics Corp. of America	8 3/8	5 5/8	6 3/4
Electronics Corp. of America	2¾	9 5/8	10 3/4
El-Tronics	9 7/8	3	3 3/8
Fairchild Camera & Instrument	25 7/8	19½	19 5/8
Globe - Union	22	16 5/8	16 5/8-17 (1)
Haseltine Corp.	48	31½	31½
International Resistance	8½	4½	5 3/4
Lear, Inc.	10½	7 3/8	8 1/8
Litton Industries, Inc.	35¢	23	34 5/8
National Research Corp.	29 3/4	16½	17½
Neptune Meter	36	28 3/8	29½
New Haven Clock	2½	¼	½
Nordon-Ketay	14 7/8	7 3/8	8 7/8
Nuclear Corp. of America "A"	2½	3/4	1 1/8
Pneumatic Scale	26½	23 3/4	24-24 3/4 (1)
Reliance Electric	61½	38 7/8	58
Servo Corp. of America	7 3/4	5	5½
Servomechanisms	13½	8½	10 3/8
United Shoe Machinery	61 5/8	40½	41½
Wallace & Tiernan	32½	19½	29½
Waltham Watch	3	1½	1 7/8

January 17, 1957

OVER-THE-COUNTER	BID	ASKED
Aerovox Corporation	4 3/4	5½
Aircraft Radio Corp.	18 3/4	19½
Argus Corp.	17	18 1/8
Barry Controls, Inc.	9½	10½
Eitel-McCullough Co.	34½	36
Electronic Associates, Inc.	55	61
Elox Corp. of Michigan "A"	9 3/4	10½
Elox Corp. of Michigan "B"	9 3/4	10½
Erie Resistor Corp.	19½	20½
G. M. Giannini	11 3/4	12½
I-T-E Circuit Breaker	34½	35 3/4
Liquidometer Corp.	8 3/4	9½
P. R. Mallory & Company, Inc.	46½	47½
W. L. Maxson Corp.	7 3/4	8½
Penn Controls, Inc.	20½	22
Speer Carbon, Inc.	31½	32½
Sprague Electric Co.	37 3/4	39
Taylor Instrument Co.	65	67
Telecomputing Corp.	4 7/8	5 3/8
Topp Industries, Inc.	8 3/4	9½
Varian Associates	16½	17½
Vitro Corp. of America	21 3/4	22 3/4

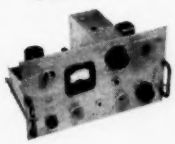
TECHNIQUES and DEVELOPMENTS
in oscillographic recording



FROM
SANBORN

PHASE SENSITIVE DEMODULATOR PREAMPLIFIER PROVIDES A DC VOLTAGE PROPORTIONAL TO AN INPHASE COMPONENT OF AN AC VOLTAGE WITH RESPECT TO A REFERENCE.

THE measurement of the amplitude of an AC voltage component is often necessary in performance studies of servo systems or of suppressed carrier signals over the carrier frequency range from 60 to 10,000 cps. In such cases the demodulator responds to inphase signals and rejects quadrature signals.



A circuit with these characteristics for use in an oscillographic recording system can be seen in the Model 150-1200 Servo Monitor (Demodulator) Preamplifier. It was developed by Sanborn as one of twelve interchangeable, plug-in front ends for "150" Series equipment, to be used with the appropriate Driver Amplifier-Power unit in any channel of a "150" system. Elements comprising the circuit from input to output, include: compensated stepped attenuator and cathode follower input circuit, phase inverter, push-pull mixer and demodulator stages, differential DC output amplifier and low pass filter. In addition, the chassis contains a VTVM to facilitate accurate adjustment of the reference voltage, and an overload indicator which lights a warning lamp when excessive quadrature voltages exist.

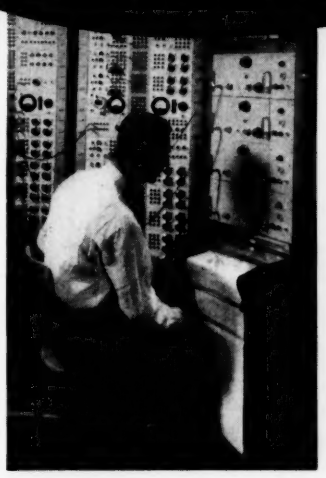
Adaptability to a fairly wide variety of applications is accomplished through broad input voltage, reference voltage and frequency ranges. In order, these are 50 mv to 50 v (for full scale 5 cm deflection), 10 v to 125 v; 60 cps to 10kc. Rise time with low frequency plug-in demodulation filter is 0.1 seconds; with high frequency filter, 0.01 seconds. Quadrature rejection is better than 100.1; for carrier frequencies up to 5000 cycles.

Two representative uses of the Servo Monitor Preamplifier are in the design and adjustment of servo systems, and with instruments used in the design, development or adjustment of other apparatus. The first is illustrated by use of the Preamplifier and associated equipment in the recording of the output shaft amplitude and driving frequency of an AC positional servo; the second by recordings made with a similar setup of the difference between output signals from a gyroscopically-controlled stabilizing device and the "pitch" and "roll" signals generated by a "Scorsby Table" used for testing the device under dynamic conditions.

For a detailed discussion of the principles and design considerations involved in the Servo Monitor Preamplifier, refer to the February, 1955 issue of the Sanborn RIGHT ANGLE, for Dr. Arthur Miller's article on "Measurements with the Servo Monitor Preamplifier."

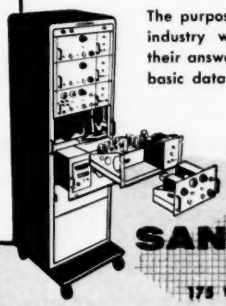
•

Technical literature and engineering assistance on specific problems are always available from our engineering department.



BASIC FACTORS IN SELECTING OSCILLOGRAPHIC RECORDING EQUIPMENT

WHEN considering any oscillographic system or equipment for your application, three useful "yardsticks" to apply are (1) the recording method, (2) equipment adaptability, and (3) variety of equipment available. Here are the answers to the three, as they apply to Sanborn systems. In the record, rectangular coordinates accurately correlate multiple traces, simplify interpretation and eliminate errors. Permanent traces, produced by a hot ribbon stylus without ink, provide sharp peaks and notches, and clearly reveal all signal changes. One percent linearity results from current feedback driver amplifiers and high torque galvanometers of new design; maximum error is ¼ mm in middle 4 cm of chart, ½ mm across entire chart. From the standpoints of "adaptability" and "variety", Sanborn "150" equipment offers the versatility of 13 different plug-in front ends for any basic system . . . the choice of one- to eight-channel systems . . . the variety of nine chart speeds, timing and coding controls, console or individual unit packaging . . . availability of equipment as either complete systems or individual amplifier or recorder units.

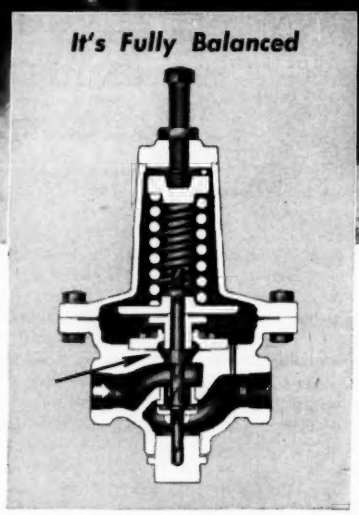


The purpose of the foregoing information is to better acquaint industry with typical oscillographic recording problems and their answers, design considerations in Sanborn equipment, and basic data on what Sanborn makes and how it is being used.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 WYMAN STREET, WALTHAM 54, MASS.

For more information circle **29** on inquiry card.

Here is the new LESLIE "HI-FLO" Water Reducing Valve with 50% more capacity



Unique construction of "Hi-Flo" Reducing Valve. Note the small lower diaphragm that provides fully balanced, floating action.

HERE IS THE ALL NEW Leslie Reducing Valve with *capacity-regulation* features that have never been offered before. Here is a regulator with 50 - 100% greater capacity by actual test.*

Hers's the unbeaten combination of design features:

"HI-FLO"—Large bowl construction; long stroke diaphragm gives full flow of water and other non-corrosive liquids.

FULLY BALANCED—The main valve, fully balanced by lower diaphragm, virtually floats to provide smooth, friction-free, throttling action.

DROP-TIGHT SHUTOFF—Resilient seating disc provides tight closure under all conditions.

TROUBLE-FREE DESIGN—Chatter and hammer eliminated; no piston cups or seals to clog or change. Corrosion resistant trim with renewable interchangeable fit.

Ask your Leslie Engineer to show you how the exclusive Leslie "Hi-Flo" valve can be used to your advantage in water reducing stations, fuel oil pressure control, process lines, etc. He's in your classified directory under "Valves" or "Regulators".

Write today for Bulletin 553 for graphic performance comparison and complete capacity data.

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., 299 GRANT AVENUE, LYNDHURST, NEW JERSEY

CONTROLLED QUALITY MEANS QUALITY CONTROLS

For more information circle **30** on inquiry card.

New Plants and Mergers

CLARK CONTROLLER CO. announces a new 70,000 sq ft plant opened by Canadian Controllers, Ltd., its Scarborough, Ontario, subsidiary.

HEWLETT-PACKARD'S new affiliate, Dynac, Inc., (*-dy-*) is designed to serve customers who need specialized instrumentation, such as complete multichannel automatic data handling systems.

FEDERAL TELECOMMUNICATION LABS. announces a new laboratory to do development work on carrier and other advanced telephone communication apparatus.

FAIRCHILD CAMERA AND INSTRUMENT CORP'S. Electronics Div. has moved into its new headquarters on Aerial Way North in Landia Industrial Park, Syosset, L. I., N. Y.

SERVOMECHANISMS, INC., has opened new corporate offices at 445 Park Ave., New York City.

POLYTECHNIC RESEARCH & DEVELOPMENT CO., INC., has taken an additional floor in their building to further development of a molecular beam oscillator.

GENERAL ELECTRIC CO. announces it will convert its Buffalo TV picture tube plant to transistors early in 1957.

FISCHER & PORTER CO. announces a new sales office in Indianapolis, Ind.

ROBERTSHAW-FULTON CONTROLS announces acquisition of all the assets and business of Acro Mfg. Co.

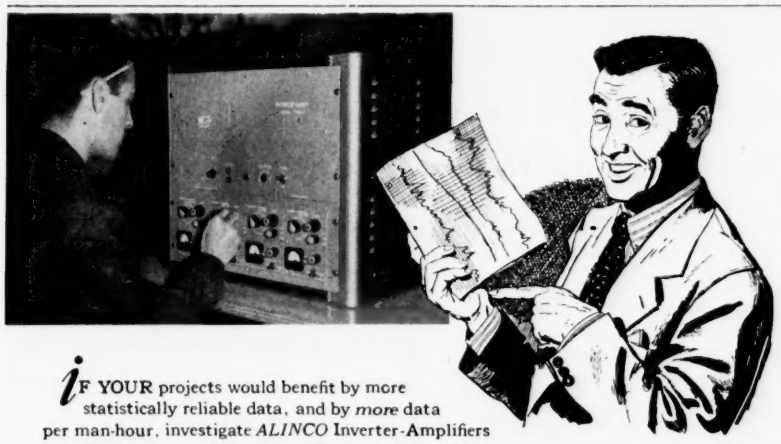
of Columbus, Ohio. The Bridgeport Thermostat Div., has opened a new $2-million plant in Milford, Conn.

INTERNATIONAL BUSINESS MACHINES CORP. announces that control of its nationwide service bureau operations has been transferred to The Service Bureau Corp., a subsidiary.

MAGNETIC AMPLIFIERS, INC., announces formation of its new West Coast Div. at El Segundo, Calif., for magnetic and transistor servo amplifiers.

THE BRISTOL CO. has opened a new branch factory and warehouse in Houston, Texas.

FISHER GOVERNOR CO. announces its new representative for Boston and New England is Clarence B. Petty & Co., Needham Heights, Mass.



DO YOU NEED

HIGH performance

AMPLIFICATION for galvanometer oscillographs ?

IF YOUR projects would benefit by more statistically reliable data, and by *more* data per man-hour, investigate *ALINCO* Inverter-Amplifiers for galvanometer oscillographs. Because of their high output, (±60 ma.), they give greater deflection of the pointer on low-sensitivity units. If you've ever tried making thermocouple studies in conductive materials, you already know that a balanced input is essential for reliable records, as well as for reducing the effects of stray pick-up. Overload indication plus no operational delay after an overload, together with high gain resolution, can understandably give you much more data per man-hour expended.

extras...

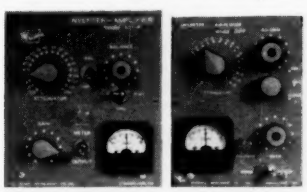
In addition to the features just mentioned, these amplifiers have low drift, low noise level, a wide frequency response of 0 to 5000 cps., phase sensitivity, and will accomodate virtually any galvanometer you have or plan to install.

These features provide you with a *HIGH PERFORMANCE* amplifier -- an amplifier that has been *field-proven* superior for performance vs. life characteristics -- fully guaranteed by *ALINCO*. Write or call now for technical literature and for application consultation.

ALLEGANY INSTRUMENT COMPANY, INC.

ALINCO

1091 Wills Mountain
Cumberland, Maryland



For more information circle **31** on inquiry card.

Sometimes you can guess at torque . . . BUT

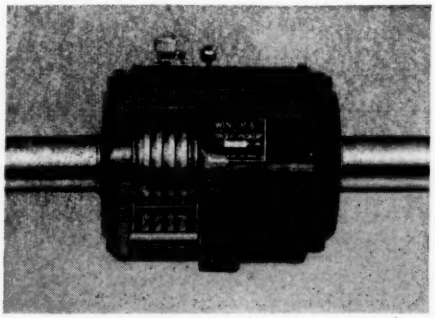
With SR-4® Torquemeters, you can measure and control all industrial torques to ±¼% accuracy

It isn't necessary to measure the exact amount of torque in order to wring out a dishcloth. But in industry, it's often vital that the exact amount of torque on a shaft be known.

You can use Baldwin SR-4 Torquemeters to measure a few inch-ounces or thousands of foot-pounds, and with consistent accuracy to within ±¼%. They convert torsion changes directly into changes in electrical energy, measure torque independently of speed, and take no power from the drive shaft. A wide variety of instruments can be used with SR-4 Torquemeters, ranging from millivoltmeter and battery to a computing instrument reading horsepower directly.

Baldwin SR-4 Torquemeters offer unlimited application opportunities. Present uses include torque measurement of viscosity, in engine dynamometers, for pump testing, in propeller drive shafts and helicopter rotor assemblies, and hundreds of other applications in design and production testing.

Whatever *your* torque measurement problem, a B-L-H representative is ready to serve you. For more complete information on SR-4 Torquemeters, write today for your free copy of Bulletin 4308.



The Type A SR-4 Torquemeter is a self-contained unit with housing and brush assembly suspended on a shaft by ball bearings. It employs SR-4 Bonded Wire Strain Gages in a Wheatstone bridge circuit. Baldwin torquemeters have been built for shafts from ¼ in. diameter to 18 in.; for zero rpm to 35,000 rpm; and from 10 in.-oz. capacity to 4,200,000 in.-lb.

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division

Waltham, Mass.

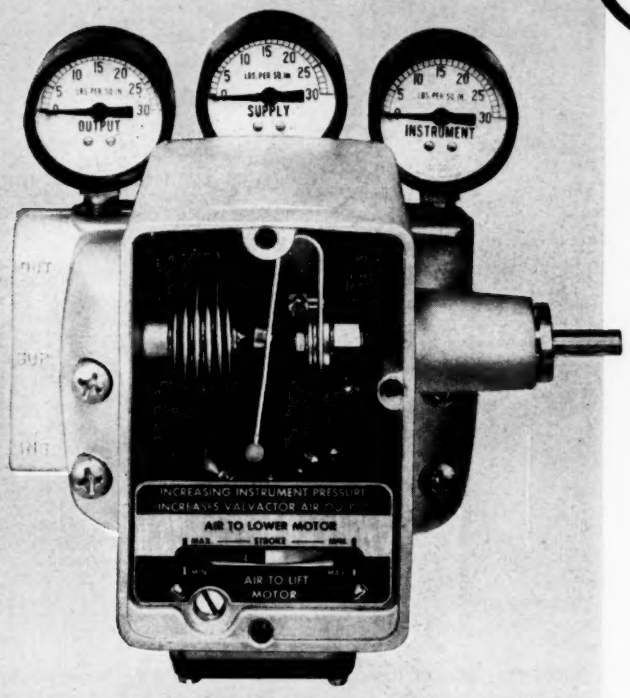
SR-4® strain gages • Transducers • Testing machines

For more information circle **32** on inquiry card.

NEW!

MOST UNIVERSALLY ADAPTABLE VALVE POSITIONER ON THE MARKET!

...the Foxboro Type C VERNIER VALVACTOR*



The Type C Valvactor's distinctive motion-balance principle of stem positioning eliminates loading effects of heavy fixed-stroke actuating springs. Note compactness — the simplest mechanical design of any valve positioner.

**Trademark of a precision valve positioner made by The Foxboro Co.*

Unique Flexibility Easily reversible in seconds. Sequencing by two simple adjustments.

Super Response Full air-pressure output to diaphragm motor on signal air-pressure change as small as ½ of 1% of signal span.

Extra Speed New, high capacity relay provides high speed positioning action.

Positive Positioning Direct, motion-balance feed-back assures instantaneous, pin-point positioning.

Now there's a positive-action, super-precision valve positioner that you can easily adapt to *any* diaphragm motor application — without exchange of parts! It's the Foxboro Type C Vernier Valvactor with unique motion-feedback.

The Type C Valvactor has a master setting disc which provides easy change of action as required by the control system, as well as easy reversal of Valvactor action for air-to-open or air-to-close control valves. Adjusting for limited stem travel is equally simple ... sequencing of several valves is a cinch!

The Valvactor is the ideal solution to such problems as stem friction, plug friction, valve motor and transmission line lag, and extreme process line pressure changes. And it requires practically no maintenance! Available with 3-gauge and by-pass manifold, or plain manifold. Write for full details.

The Foxboro Company, 462 Neponset Ave., Foxboro, Mass., U.S.A.

FOXBORO
REG U.S PAT OFF
VALVE POSITIONERS

For more information circle **33** on inquiry card.

THERMISTOR DEVICES GIVE 1 TO 100 POINT TEMPERATURE CONTROL

Fenwal Units' Accuracy is .25% of Scale

ASHLAND, MASS. — Fenwal engineers here have designed a new Controller using a thermistor and a simple electronic circuit, and the result is a temperature-control system versatile and accurate to within .25% of scale.

The thermistor principle is this: the electrical resistance of the sensing element decreases as its temperature rises. The resistance changes for very small temperature changes are large, making extremely accurate temperature measurement possible.

In the Fenwal system, the thermistor, with its amazing sensitivity and fast responses, feeds an electronic bridge circuit that uses standard tubes. The small thermistor probe, available in several styles, is mounted at the point you wish controlled.

You can mount the compact Unit Controller up to 200 feet away from the control point without losing sensitivity. You can connect it with ordinary lamp cord.

Tailor-Made Designs

But possibly the biggest news in the design is the way the Unit Controllers can be assembled with a common power supply, like building blocks, to provide you with a central system serving up to 100 control points.

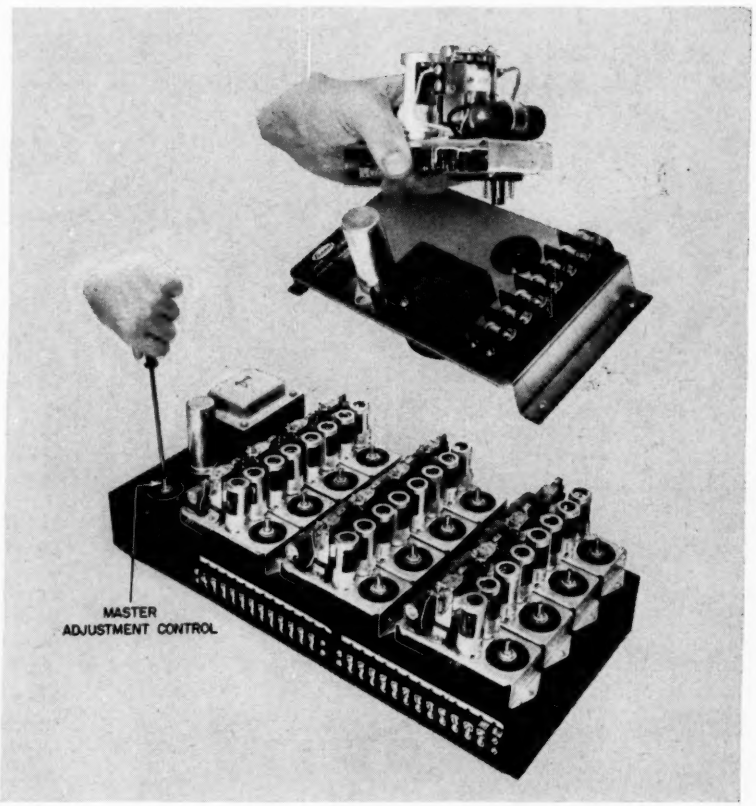
The units are, of course, ideal for use singly as well — each unit serving a single control point, each unit with its own power supply.

The many possible combinations of units are known collectively as the Fenwal Series 53000. There are four standard temperature ranges for you to choose from: −100°F to 50°F; 0°F to 150°F; 100°F to 300°F; and 200°F to 600°F. Special ranges can, of course, be supplied in most cases.

Each Controller includes a potentiometer for temperature adjustment, which you can locate remotely, if you wish. For multiple units, you can have a single master control. This control will let you adjust a complete system while permitting compensating adjustment for each individual Controller, too.

These Thermistor Controllers are already serving hundreds of companies in many industries. Why not yours? You'll be surprised how inexpensive good control can be.

Designers and process engineers — you will want to have details on this new advance in precision temperature control at your fingertips. Write for information on the Series 53000 Unit Thermistor Controllers to **Fenwal Incorporated, 362 Pleasant Street, Ashland, Mass.**



FENWAL'S SERIES 53000 UNIT THERMISTOR CONTROLLER — Serves a single temperature control point, but can be combined easily with others, like building blocks, to make up a central system serving up to 100 control points with a single master control if desired. You should know about this. Write Fenwal for details.

Fenwal

CONTROLS TEMPERATURE
. . . PRECISELY

For more information circle **34** on inquiry card.

BRUSH ELECTRONICS CO. announces appointment of *Maurice E. Eastin* as general sales manager of this division of Clevite Corp.

M. E. Eastin

T. C. Fry

REMINGTON RAND UNIVAC announces appointment of *Dr. Thornton C. Fry*, well known mathematician, as senior consultant.

ELECTRO-SNAP SWITCH & MFG. CO., Chicago, announces its new president is *Harold Ames, Jr.*

AIRBORNE INSTRUMENTS LAB., INC., announces appointment of *Dr. Bernard Salzberg* as chief scientist of their Research and Engineering Div.

W. L. MAXSON CORP. announces appointment of *F.D. Vieth* as western district manager.

DUMONT LABS., INC., announces appointment of *Burtis E. Lawton* as senior applications engineer in the Industrial Tube Sales Dept.

HAGAN CHEMICALS & CONTROLS, INC., has named *Edwin A. Cunningham, Jr.*, manager of the new Pittsburgh Production Engineering Dept.

CARBORUNDUM CO. announces election of *William H. Wendel* to newly-created position of group vice president.

People IN THE NEWS

COOK ELECTRIC CO. announces promotion of *Thomas Dunsheath* to technical director of the automatic control system section of Cook Research Labs.

T. Dunsheath

J. Stitzer

R. Sackman

BETA ELECTRIC DIV., Sorenson & Co., Inc., announces advance of *Jesse Stitzer* to chief engineer.

AMPEX CORP. announces election of *Robert Sackman* as general manager.

FEDERAL TELEPHONE AND RADIO CO. announces election of *Major General Francis H. Lanahan*, USA (Ret.), president of Federal Electric Corp. *Henry O. Wolcott* is appointed chief engineer and production manager for the Instrument Div.

HOW ANTIQUE ARE YOUR MICRO-MACHINING METHODS?

USE THE PERFECT COMBINATION
For Assured Accuracy
in MICRO-DRILLING

LEVIN®
SUPER PRECISION COLLETS

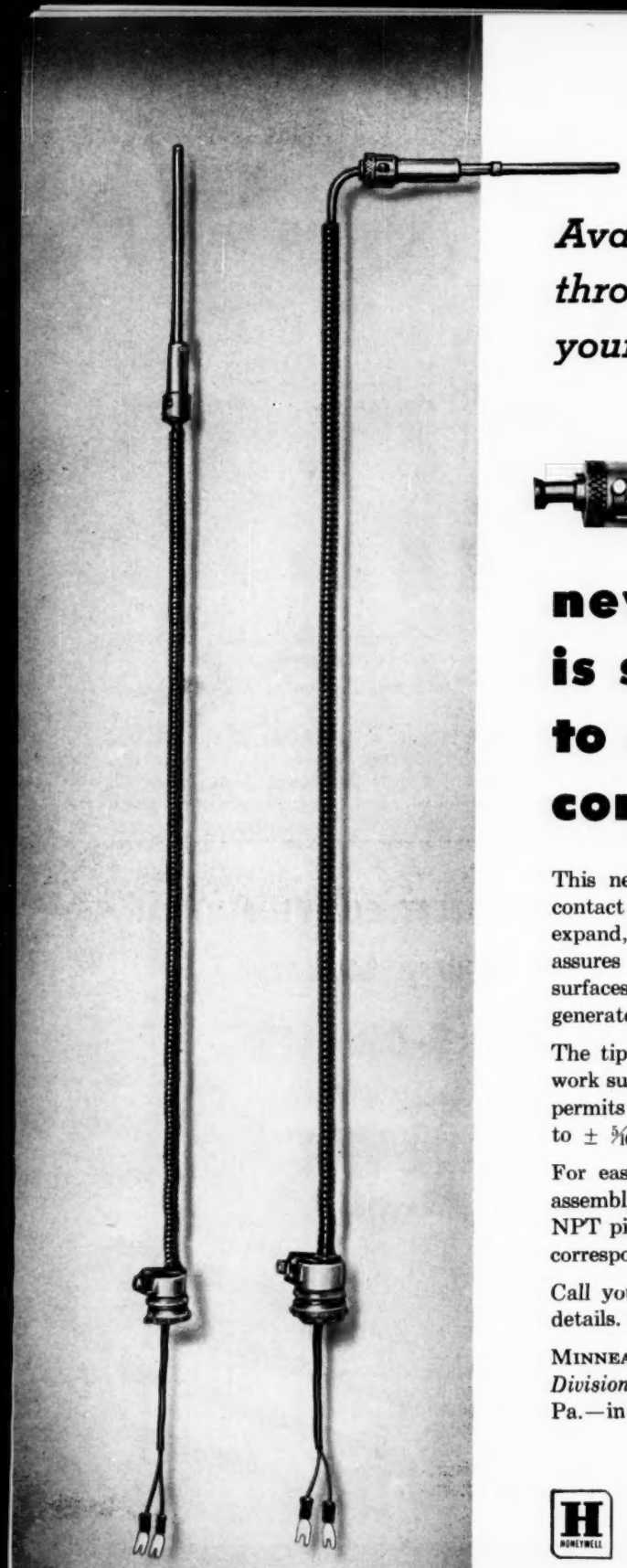
Super precision collets for jewelers type lathes. Ideal for holding micro-drills or other parts where concentricity is important. Available from stock in complete range of sizes from .004" (.1 mm) to 5/16" (8.0 mm).

SPHINX
HIGH SPEED STEEL • MICRO-DRILLS

Drills from .0016" to .0591" are stocked in increments of .0004" (.01 mm). From .0610" to .1181" in increments of .0020" (.05 mm). Left hand micro-drills for use on Swiss type automatic screw machines. Short flute center drills. Send for Bulletin "Q" listing complete line of drills or Catalog M listing collets as well as full line of instrument lathes and accessories.

LOUIS LEVIN & SON, INC.—3610 S. BROADWAY—LOS ANGELES 7, CALIFORNIA

For more information circle **35** on inquiry card.



Available in either straight or 90° angle construction for ease of installation.

Available through your...

HSM
HONEYWELL SUPPLIES MAN

new thermocouple is spring loaded to maintain continuous contact

This new Honeywell thermocouple keeps in continuous contact with the work surface, even though the surface may expand, contract or become displaced during operation. It assures accurate temperature measurement of internal surfaces such as those of plastic extrusion machines or generator bearings.

The tip of the thermocouple is held securely against the work surface by an *Inconel-X* spring. Moreover, the spring permits insertion of the thermocouple in holes varying up to ± 5/16" from the specified depth.

For easy inspection and replacement, the thermocouple assembly is provided with a bayonet adapter to fit a 1/8" NPT pipe connection. The assembly itself is fitted with a corresponding cap to engage this adapter.

Call your nearby Honeywell Supplies Man for complete details. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

New Allen-Bradley developments

GREATER COLOR PURITY—BETTER CONVERGENCE

1. FULL ROUND YOKE CORES

FOR COLOR TV

ALSO BLACK AND WHITE

Allen-Bradley has developed a method of producing ferrite deflection yoke cores as a full 360° ring! Unlike cores made from quarter rounds, the new full round cores are perfectly concentric and have parallel inner surfaces. They require no grinding. The round rings are "cracked" into halves and taped for shipment. Assembly is quick and economical. The tape is rolled back, the core is slipped over the coils, and the tape put back in place. The core's concentricity assures better convergence and greater color purity.

These ferrite yoke cores are produced as full rounds, and are "cracked" into halves and taped, as shown, for easy assembly.

2. FLARED YOKE FERRITE CORES

FOR NEW 110° TUBE . . . SAVES WEIGHT

For the new 110° picture tube, Allen-Bradley has developed a flared yoke ferrite core whose outer surface is also shaped to reduce the amount of material required. This makes possible a weight reduction of approximately 30% over conventional cylindrical cores.

The new flared yoke is produced as a solid piece but, with the Allen-Bradley method, the yoke is "cracked" into halves, yet a perfect ring is maintained. Available in Allen-Bradley Class WO-1 ferrites which are to be preferred because of their uniform magnetic characteristics.

Allen-Bradley Co.
140 W. Greenfield Ave.
Milwaukee 4, Wis.

In Canada—
Allen-Bradley Canada Ltd., Galt, Ont.

A-B Quality

ALLEN-BRADLEY

RADIO, ELECTRONIC, AND TELEVISION COMPONENTS

QUALITY

For more information circle **97** on inquiry card.

Instrumentation
research
and
flight test
engineers

find careers in

"ELECTRONIC ANATOMY"

at Republic Aviation

Action delay—the time lag between the brain sensing a signal and converting it into muscular energy—becomes critical in piloting hypersonic aircraft.

Republic Aviation, pioneer in jetcraft and missiles, needs instrumentation research and flight test engineers to develop electromechanical brains, nerves and muscles—to develop electronic neural systems with minimum action delay.

Working at Republic in electronics instrumentation you will raise the safety and performance coefficients of the men operating the most advanced mechanical ensembles yet devised.*

Here are some of the stimulating assignments awaiting you at Republic:

INSTRUMENTATION RESEARCH

- Servo Systems Analysis
- Analog Technique Development
- Automatic Data Processing
- Development of Magneto-strictive Units
- High Speed Oscillographic Recording

INSTRUMENTATION FLIGHT TESTING

- Airborne Magnetic Tape Systems
- Airborne Telemetering Devices
- Transducer Development in Recording
- Advanced Circuitry
- Flight Test Instrumentation Installation

**For example, the incredible Republic F-105 Thunderchief, most advanced and lethal hypersonic USAF fighter-bomber, capable of delivering atomic payloads.*

To learn more on career positions at Republic Aviation in electronic instrumentation, send a complete technical and personal resume to:

Mr. George Hickman
Engineering Employment Manager

REPUBLIC AVIATION

Farmingdale, Long Island, New York

Events

For Computer Events See Page 289

March 4-8
Eighth Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Pa.

March 5-8
1957 Conference on High-Speed Computers, Louisiana State University, Baton Rouge, La. For information write Frank T. Carroll, Jr., College of Engineering.

March 11-14
The IRE Professional Group on Nuclear Science is cooperating with the EJC Second Annual Nuclear Science and Engineering Congress in Philadelphia. For information write Dr. Sidney Krasik, Editor, IRE—PGNS Transactions, 5621 Wilkins Ave., Pittsburgh 17, Pa.

March 18-21
Institute of Radio Engineers National Convention and Radio Engineering Show, Waldorf-Astoria Hotel and the New York Coliseum. For more information write IRE, 1 E. 79th St., N. Y. 21, N. Y

March 19-21
151st National Meeting American Meteorological Society, Univ. of Chicago. For information write Louis J. Battan, Univ. of Chicago, Chicago 37, Ill.

March 25-28
Physical Society Exhibition of Scientific Instruments and Apparatus, New and Old Halls of the Royal Horticultural Society in Westminster, London. For information write J. E. Reeve, Commercial Dept., British Embassy, Washington, D. C.

March 26-27
Conference on Instrumentation for the Iron & Steel Industry sponsored by the Pittsburgh Section of I. S. A., Hotel Roosevelt, Pgh. 22, Pa. For information write Fred D. Marton, 845 Ridge Ave., Pgh. 12, Pa.

April 8-11
14th Annual British Radio and Electronic Component Show, Grosvenor House and Park Lane House, Park Lane, London, W. 1. For information write Andrew Reid, Radio Industry Council, 17 Fleet St., London, EC4, England.

April 10-12
First National Nuclear Instrumentation Conference, Atlanta, Georgia, sponsored by ISA. For information write Herbert S. Kindler, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

April 11-13
Ninth Southwestern I.R.E. Conference and Electronics Show, Shamrock Hotel, Houston, Texas.

April 22-24
IRD's 3rd Annual Conference on Control System Applications, Northwestern Univ., Evanston, Ill.

May 1-3
Electronic Components Symposium, Morrison Hotel, Chicago, Ill. For information write J. S. Powers, Electronic Components Symposium, 84 E. Randolph St., Chicago 1, Ill.

May 9-10
1957 Annual Meeting of the Professional Group on Microwave Theory and Technique, Western Union Auditorium, New York, N. Y.

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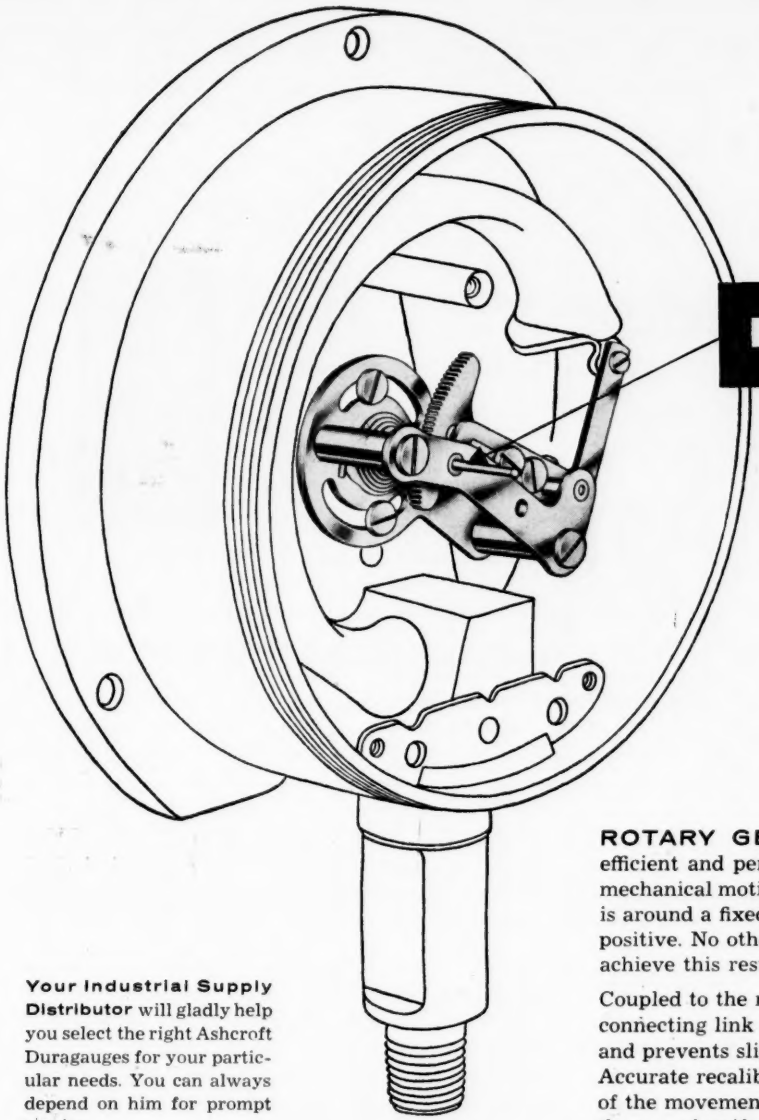

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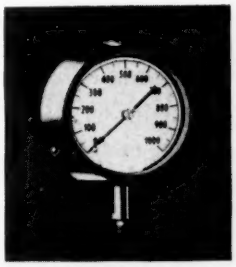

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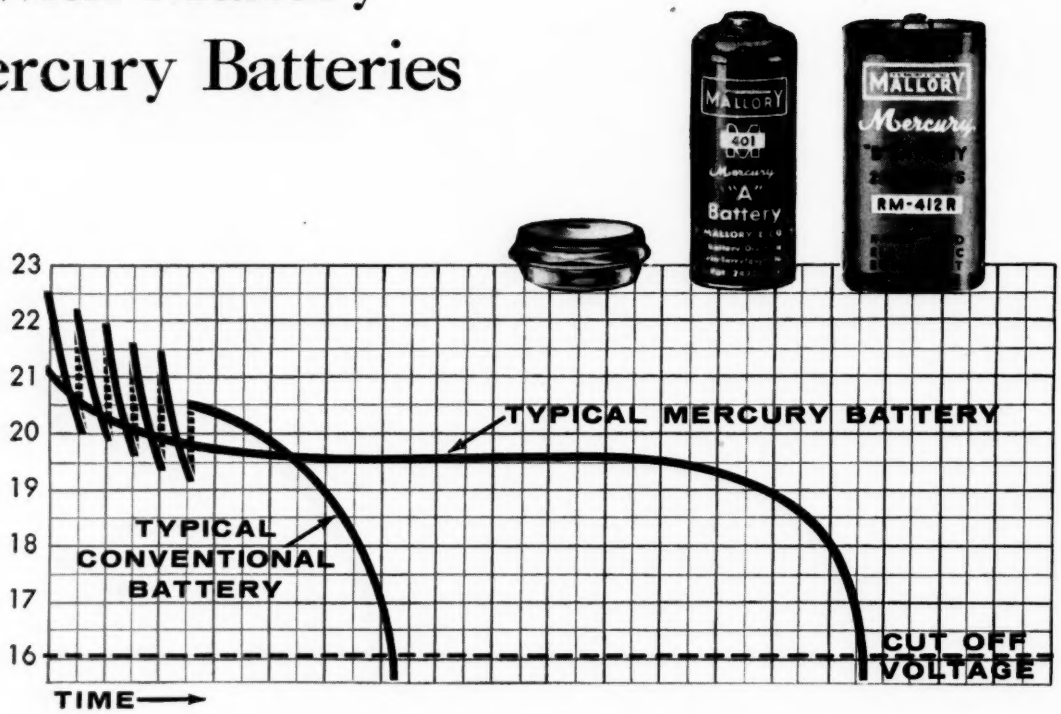
Design for fade-free service with Mallory Mercury Batteries



One of the most unusual characteristics of unique Mallory Mercury Batteries is that they stay at constant output throughout their long life . . . instead of gradually losing power like conventional batteries.

This characteristic is especially important in transistor circuits, which require a constant energy source. In instrument circuits and bias cell applications, the constant voltage output of Mallory Mercury Batteries protects accuracy and serves as a reliable secondary voltage standard.

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Write to Mallory today for technical data on the complete line of voltage and milliampere-hour ratings available, and for a consultation with a Mallory battery specialist.

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For more information circle **39** on inquiry card.

Emery NEWS

WEIGHING SYSTEM

BIN, TANK AND HOPPER EDITION **No. 3**

Covering design, development and application data on Emery Weighing Systems for industrial applications

EMERY CELLS USE HEISE GAUGES FOR MAXIMUM OPERATING ACCURACY

More than 100 years ago, Eugene Bourdon, of Paris, discovered that tubes of non-circular cross section permanently bent in the form of a semi-circle, tend to unbend if subjected to internal fluid pressures. Such tubes have become known as Bourdon tubes. Fig. 1.

The Heise Bourdon Tube Company, Inc., Newtown, Conn., has been developing and manufacturing these gauges for more than 25 years and has earned a world-wide reputation for precision workmanship and precision accuracy.

We were the first to use these Heise gauges in our testing machine work and we have continued to apply them to the present Emery Weighing Systems.

In remote indication applications, specially installed Emery indicators have proven satisfactory for distances up to 125 feet. The quick response of these indicators is due to the relative incompressibility of the hydraulic fluid in the system. The cell will automatically compensate for any volumetric changes in the weighing system without sacrificing accuracy. Pressure from the Emery Cell to a suitable indicator, recorder or controller is carried through ⅛" copper tubing. Fig. 2.

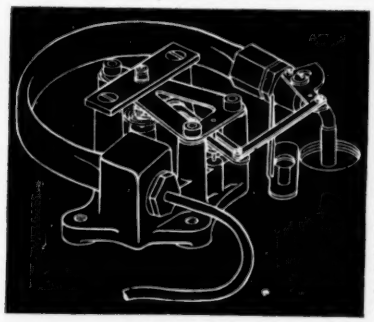


FIGURE 1

SIMPLEST APPLICATION OF EMERY WEIGHING SYSTEM INVOLVES ONE CELL AND APPROPRIATE INSTRUMENTATION

TANK, BIN OR HOPPER MAY BE SUPPORTED OR SUSPENDED

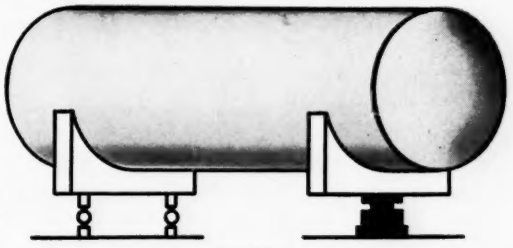


FIGURE 3

The tank shown in Fig. 3 is one of the simplest arrangements of an Emery Weighing System utilizing the new "Rolling Ball" Load Cell. It consists of one Emery Cell to support the front end of the tank and two Emery Ball Pivot Assemblies or some other support such as an "I" beam for the back of the tank.

The hydraulic pressure in the cell actuates an indicator, recorder or controller which is so calibrated that it reads directly the weight of the tank contents.

The basis for the arrangement of the tank shown in Fig. 4 lies in the use of a compression cell and a carrying structure to seat the load directly on the cell.

The alternate arrangement, shown in dotted line, involves the use of a tension cell supported from the floor above with the weight of the tank suspended on a rod which would go directly through the cell.

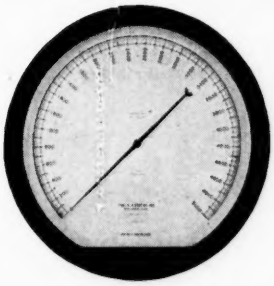
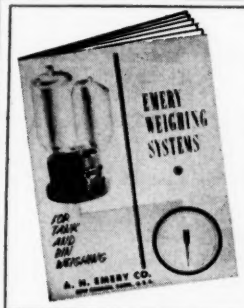


FIGURE 2



NOTICE

These are but three of the fifteen different arrangements discussed in detail in our new Bulletin 561. If you have not yet received a copy, be sure to write today or check the proper number on the Readers' Service Card in this publication. We will be happy to send you a copy by return mail.

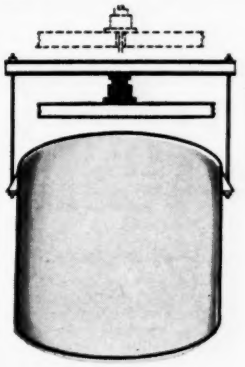


FIGURE 4

THE A. H. EMERY CO. PRECISION SINCE 1872 FORCE MEASUREMENT

THE A. H. EMERY COMPANY

Pine Street • New Canaan, Conn.

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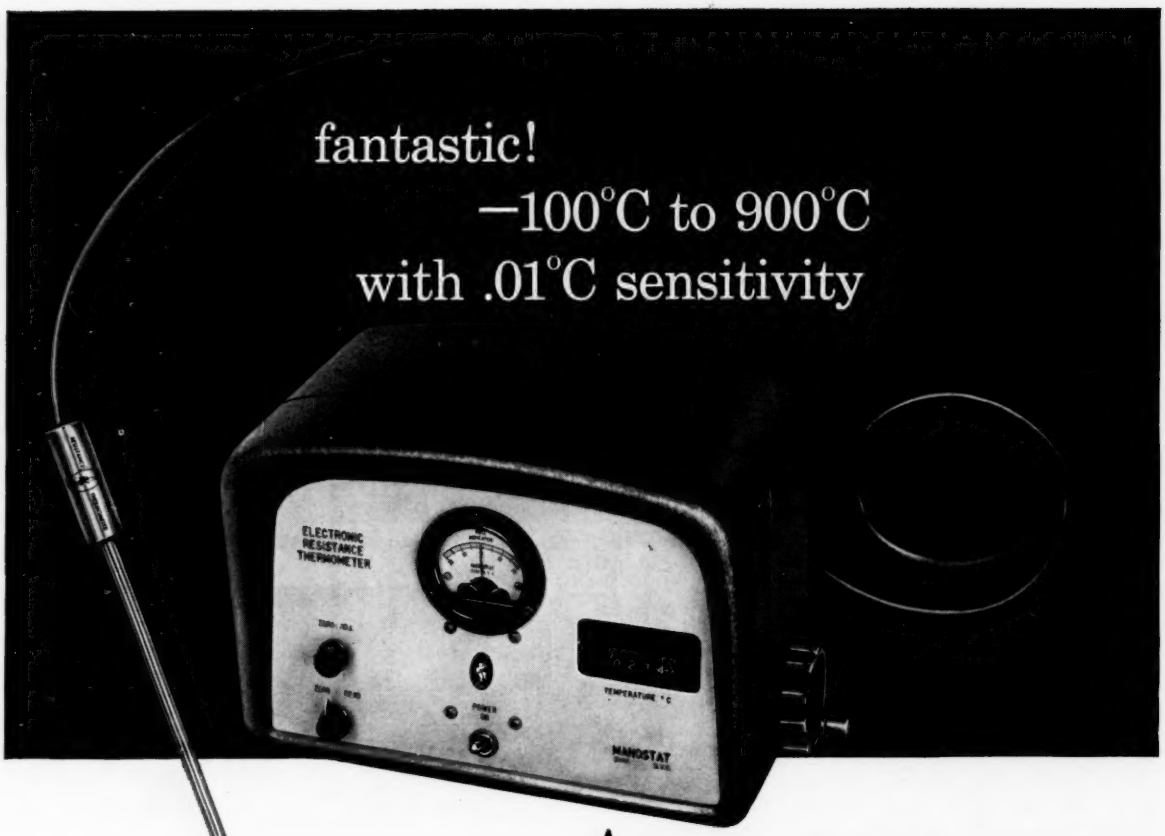

Absolutely incredible... but absolutely true! For the first time ever, here is the *only* thermometer which covers a range from −100°C to 900°C, with .01°C sensitivity and digital reading of temperature directly.

read temperature directly · no calculations necessary

- ▶ High Accuracy
  .10°C up to 400°C .20°C up to 900°C
- ▶ Each resistance bulb and bridge individually calibrated.
- ▶ Vacuum sealed platinum elements and leads in resistance bulb:
  - Hermetically sealed head
  - Choice of stainless steel or quartz jacket
- ▶ Plug-in controller accessory with .05°C reproducibility.

ELECTRONIC Resistance Thermometer

HOW IT WORKS:

By means of a special circuit in the Wheatstone bridge, the reading of the balancing variable resistor is made to follow a second degree relationship corresponding with the change in resistance of platinum with temperature. This gives a direct reading instrument which eliminates the time consuming calculations normally required with high precision resistance thermometry. A high sensitivity electronic detector permits rapid and precise balancing of the bridge.

PRICE LIST:

23525	Electronic Resistance Thermometer without bulb. Either 23525D or 23525E or both must be ordered at the same time as the thermometer and these will be individually calibrated	1105.00
23525D	Stainless Steel Bulb, only	395.00
23525E	Quartz Bulb, only	395.00
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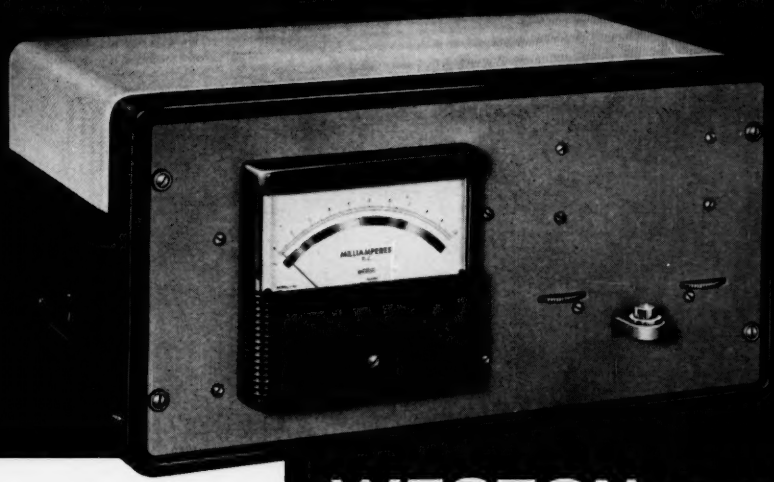
A New Analog Multiplying Element



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PRODUCT RESOLVER

— produces a direct current proportional to the product of two varying electrical signals

- four-quadrant operation
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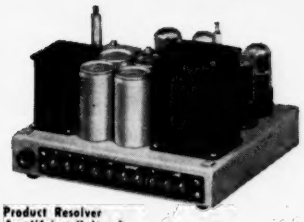
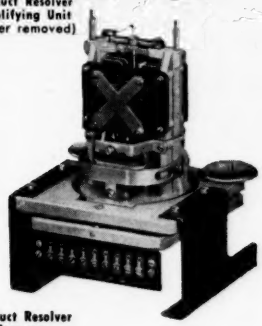
- especially suited to a-c d-c measurements



Product Resolver Amplifying Unit (cover removed)



Product Resolver Converter (cover removed)

WESTON
INSTRUMENTS

A DAYSTROM UNIT

This Weston Product Resolver employs an electronically balanced electrodynamometer instrument mechanism to develop a product output signal from two input signals by torque multiplication. The Inductronic® balancing system provides precise and rapid response, and an exceptional order of response to displacement. The mechanism is unique to this purpose and stems from Weston's long experience in the design and manufacture of precision dynamometer mechanisms. The complete story on the Model 1482 Inductronic Product Resolver can be obtained from your local representative or by writing Weston Electrical Instrument Corp., Newark 12, N. J., A subsidiary of Daystrom, Inc.

For more information circle **42** on inquiry card.

ANNOUNCING

NEW | fire resistant impact resistant

DEKORON INSTRUMENT TUBING HARNESS

FLAME RETARDANT OUTER SHEATH
FIREPROOF AA ASBESTOS
EXTRA HEAVY THERMAL and SHOCK ABSORBER
NEW LINEAR POLYETHYLENE
YOU CAN BURN IT
YOU CAN BANG IT
YOU CAN BURY IT

You can't beat all-plastic Dekoron Poly-Cor for chemical resistance or for ease of installation. And now, the *new* Dekoron Instrument Tubing Harness adds yet another revolutionary feature—*fire resistance.*

For example, in the direct flame of a cutting torch, it lasted longer than any other multiple-tube harness. Use it in areas where flash fires are a hazard. And *new* Dekoron Instrument Tubing Harness is rugged, too. You can bury it and forget it.

You get all the advantages—chemical, impact and fire resistance—with *new* Dekoron Instrument Tubing Harness. Remember, you can burn it . . . you can bang it . . . you can bury it. And you can *buy it now.* AA-4368

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SIGNIFICANCE

Carbide and Carbon Chemicals Company (a Division of Union Carbide and Carbon Corporation) designs, builds, and operates plants—from titanium plants to nuclear reactors. E. Ivan (Tommy) Thomas is Chief Instrument Engineer and Assistant in Charge of the Instrument Division of Carbide and Carbon Chemicals Company, South Charleston, W. Va., a key position within a key phase of industrial instrumentation.

The Carbide and Carbon Chemicals Company at South Charleston produces many of the company's bulk organic chemicals such as acetic anhydride, ethanol, the butyl compounds, and many of the so-called "fine chemicals." The South Charleston plant was the first of the Chemicals Company plants to produce and ship Prestone anti-freeze, and Vinylite and Polyethylene resins. Also located at South Charleston are the Research and Development centers and the Chemicals Company Design and Construction Engineering groups. These latter groups are dependent upon one or more of the Instrument Division's departments for instrumentation problems.

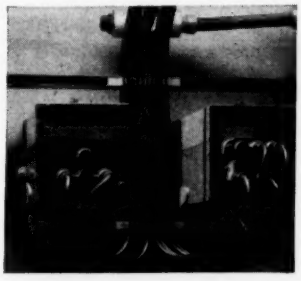
INSTRUMENTS and AUTOMATION

Biographies of significance

Mr. Thomas, well known as "Tommy" throughout the field, has been behind several developments of our field that must be rated near the top of any listing of important instrument developments of our time. For example, he was the developer of polyethylene plastic tubing for instrument air service (see *I&A*, October, 1954), which changed the entire cost picture of the pneumatics vs electronics debate and restored pneumatic instrumentation to a competitive position vis-a-vis electronics. We are proud to acknowledge Tommy Thomas' unique and fundamental contributions to our field, and his important position within it. Typical instrument activities at his plants are shown on pages 258 and 259.

E. IVAN THOMAS

E. Ivan Thomas, better known as Tom, started his career in instrumentation with Carbide and Carbon Chemical Company, South Charleston, W. Va., late in 1933. Graduating from West Virginia University with a major in chemistry and minors in physics and business administration, he was employed in the Meter Department of Carbide to await a transfer to the Control Laboratories. Needless to say, this transfer was never made.



Tommy's pioneering work in the development of "instrument-quality" plastic tubing changed the cost picture for pneumatic instrument installation. Tommy's newest article "Cost of Pneumatic Control Systems," will appear in our March issue.

Tom was instrumental (no pun intended) in applying conventional industrial controls, as they existed in 1934, to approximate composition changes in continuous distillation columns. Early in 1935 he was sent to Whiting, Indiana, as an instrument engineer, to help in the start-up of the new plant built there by Carbide. Later that same year he spent considerable time in developing an ethylene purity analyzer.

Practically all facets of Carbide's instrument work have at one time or another been Tom's responsibility. Under his supervision a file system was originated for the permanent records of all the major instrument items used within the South Charleston Plant to provide statistics as to the location and service history of each instrument. In order to operate an instrument store during World War II with untrained personnel, handling approximately 15,000 items, a system for identification, inventory control, and accounting was devised and is still in use today. Many other procedures and duties were set up under his supervision to develop a fast-growing instrument group into an Instrument Division with a minimum of red tape and personnel.

Some of his major engineering jobs have been the instrumentation of plants for the production of styrene (used in the manufacture of artificial rubber during World War II), complete instrumentation of the initial Chemicals Company plant at Texas City, Texas, and the responsibility of instrumentation engineering pertaining to all new plants and major additions to the existing plants for the Chemicals Company in the United States—and also for foreign countries. Tom has acted as Carbide's Chemicals Company consultant on instrumentation for such new projects as UCC Silicones Division plant, the Electro-Metallurgical Company's titanium plant, and for the ANIC SpA plant for Italy, as well as many others.

Some of his developments, in addition to crude type analyzers in the '30's for ethylene and oxygen, are mechanical designs for automatic devices that are largely responsible for converting some types of batch proc-

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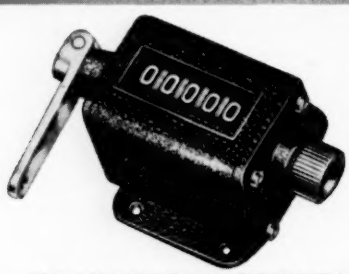
Why is COUNTROL

important in every business today?

Countless times a day, every business needs to know "how many? . . . how much? . . . how far? . . ." and many other questions that can be answered only by facts-in-figures. But how to get these figures . . . from so many different machines, processes, operations and systems? Veeder-Root Counters are doing it every day, by means of:



MECHANICAL COUNTING

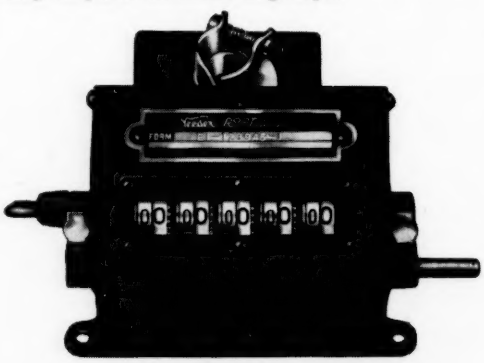
Small Resets count strokes, turns, or pieces . . . are used by thousands for moderate duty in parts inspection, quality control, conveyors, machine tools, light presses, etc.

HAND COUNTING

Where objects or units cannot be counted electrically or mechanically, hand-operated counters like this Hand Tally do the job. For instance, quick spot checks of production or performance, traffic count, inventory, etc. Fits palm of hand, counts one for each pressure of thumb lever, resets to zero by turning knob.

ELECTRICAL COUNTING

These remote-indicating counters bring your production machines as close as your office wall. AC or DC, they can be connected in series with any simple switch, and will transmit production figures *instantly* over any distance. May be panel-mounted in groups.



CONTROLLING

Set it for the exact number of turns, pieces, or operations required . . . and this Predetermining Counter will control the run *exactly* . . . preventing over-runs and shortages. When the predetermined number is reached, counter will light a light, ring a bell, or actuate a stop-motion.

IN SUM: *If it can be counted or controlled . . . count on Veeder-Root to do it. Get in touch with your Industrial Supply Distributor for standard counters for application to your production machines and processes. And get in touch with Veeder-Root for counters to be built into original equipment.* **Veeder-Root Inc., Hartford 2, Connecticut.**

Insist on Standard

VEEDER-ROOT COUNTERS

from your Industrial Supply Distributor

VR®

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esses to semi-continuous processes, as well as a successful valve for super-pressure applications, and a novel purge unit for the addition of inert gas to instrument leads.

Some of his most recent developments are the multitube polyethylene vinyl sheath tubing for instrument air service, which has been used to simplify and reduce the costs of installing instruments (installations totalling over 125 miles of this tubing have been successfully used by Carbide), the simplification of unit panel construction, and a novel graphic panel using a projector and slides of the pertinent flow sheet data.

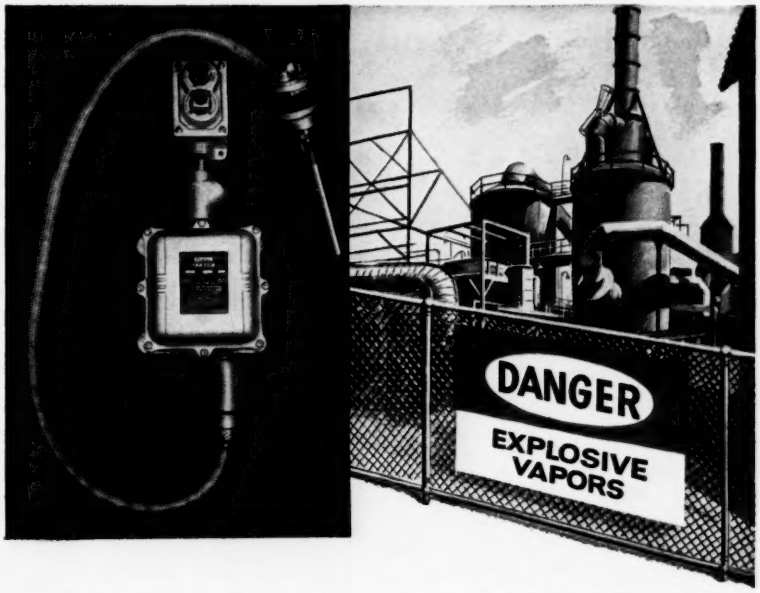
Tom keeps well informed on new developments in the field of instrumentation by reading and scanning technical magazines and by working closely with the technical personnel of many instrument companies. He has also developed better methods and new uses for materials to apply and install instruments, the results being considerable savings to his company. To aid in these developments, economic studies are made and an Engineering Test Laboratory is operated to evaluate major new instrument items, materials, and ideas.

Tom has been a subscriber to *I&A* since the late 30's. He tells us, "Since starting in this broad field of endeavor, I have used the issues dating back to Vol. 1, January 1928, as a reference and text to learn about instrumentation. The magazine *I&A* is subscribed to by Carbide here at South Charleston and is routed to all of the instrument engineers and to others within the Division. I, of course, have my own personal copy."

At present, Tom is Chief Instrument Engineer and Assistant in Charge of the Instrument Division of Carbide and Carbon Chemicals Company at South Charleston, which consists of a Special Instrumentation Department for research and development, a Chemicals Company Instrumentation Engineering Department, an equivalent department for the South Charleston plant, and a Plant Maintenance Department. The total personnel employed by all these departments is 160.

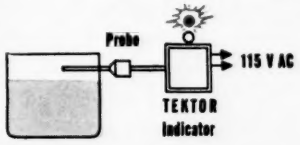
Tom is married to Mary K. Adams, who was formerly an instrument engineer for Carbide, and has three sons —Charles 15, Clifford 4, and Bruce 2. His favorite hobbies are fishing and working on projects around the house, and he enjoys a good football game, a boxing bout, or a hockey match.

TEKTOR® Electronic Level Control safe for hazardous locations



Practically every plant can improve level control electronically—and meet safety requirements—now that the entire Fielden TEKTOR System is UL listed and FM approved for Class I, Groups C and D, and Class II, Groups E, F and G, hazardous locations.

This explosion-proof unit features a specially-designed ferralloy housing and Teflon* insulated probe. Available for fail-safe high or low level control, it features the same simple and versatile capacitance circuitry found in the standard TEKTOR unit.



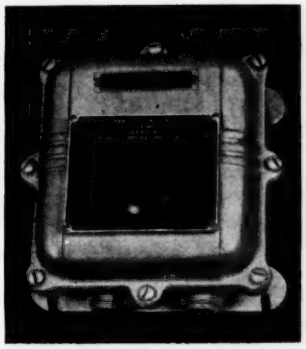
As level changes, capacitance at the probe also changes and energizes a relay. TEKTOR flashes a warning and can operate controls to keep level from exceeding desired limit.

*Trade-mark for Du Pont tetrafluoroethylene resin.

TEKTOR features

- Controls level of liquids, liquid interface, powders, granular solids (conducting or non-conducting)
- Responds to changes as small as 1/16" in aqueous solutions
- No moving parts—only one radio tube

NEW EXPLOSION-PROOF TEMPERATURE CONTROLLER



Fielden's sensitive Series 97 Controller is now available in explosion-proof design for hazardous locations. Used with resistance temperature detectors, this controller actuates two-position control devices with changes as small as ±0.2° F. Ranges from −330° F. to +1382° F. Lamps show whether temperature is above or below control point setting.

Write for literature

Robertshaw-Fulton
CONTROLS COMPANY
FIELDEN INSTRUMENT DIVISION
Dept. A, 2920 N. 4th St., Philadelphia 33, Pa.

For more information circle **45** on inquiry card.

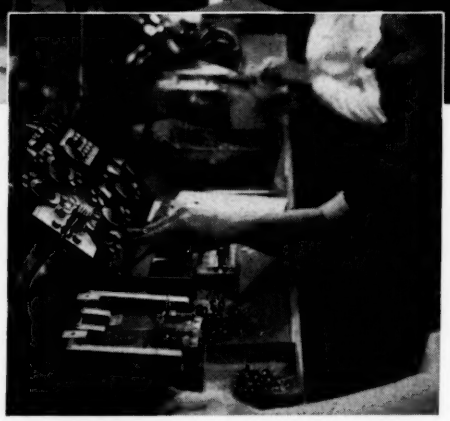
Operators in the foreground are trimming resistors down to close approximation of their final values, guided by L&N No. 4760 Bridges.

88 L&N Bridges work ROUND THE CLOCK on resistor calibration

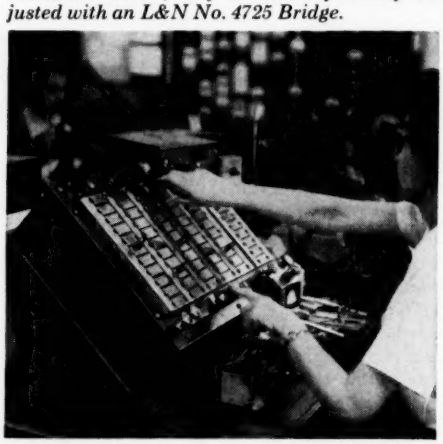
Continuous operation on production work is an exacting job for any precision instrument. But Resistance Products Company, Harrisburg, Pa., depends on L&N Bridges to measure precise resistors on a two and three shift basis. Some bridges have been in operation as long as nine years without any attention except routine maintenance.

Low maintenance and high precision are especially valuable, since many RPC resistors must be adjusted to a high accuracy, for use in guided missiles, computer networks, printed circuits, etc.

If we can help you select instruments for similar applications, from L&N's line of rugged, precise bridges, galvanometers and potentiometers, just let us know. A Field Engineer will either call or send printed information as you wish. Please write us at 4955 Stenton Avenue, Philadelphia 44, Pa., for Data Sheet Group E-53 describing L&N Bridges.



After the resistors are annealed to stabilize their resistance values, they are more precisely adjusted with an L&N No. 4725 Bridge.



If an even higher degree of accuracy is required, the resistors are further adjusted with an L&N No. 4230 Anthony Pattern Bridge.

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INSTRUMENTS and AUTOMATION

AUTOMATION: The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts.—*M. H. Aronson*, Editor

Editorial

Instrumentation—1956

MANY exciting statistics can be cited to dramatize the growth and development of the instrument field in 1956, but figures are deceptive unless analyzed in terms of population growth and inflationary price increases. It is more useful to examine the specific concepts and ideas and equipments that received the most attention and had the greatest impact.

Instrumentation developments in 1956 should be discussed in two broad categories—concepts and hardware.

The new concept that received the most attention in the technical press was the "systems concept," a term applying to the analytical engineering approach to the control of an entire operating system, as opposed to control of its sub-units. The systems concept broadens the control function to include considerations heretofore considered managerial, and the year saw the emergence of several firms with excellent theoretical backgrounds specializing in "systems engineering." However, the year 1957 began with a huge gap between the theory and practice of such systems engineering. Practical application of systems engineering presupposes intimate and detailed information on the response characteristics and transfer functions of every unit in the system, which data are not at present available or attainable by the consulting agencies.

Systems engineering will become practical when it becomes possible to obtain the response characteristics of every unit in the system. Work is now underway on developing these data—but the question is still unresolved as to whether the data should be obtained by the men in the plant, who know the plant but who do not know the systems concept, or by the men who know the concepts but who do not know the plant. This is the unresolved question of 1956—and a big problem for 1957.

A second basic concept emerged as the year ended—optimal control. Control of a process via one or more of its variables has been the established method. The advantages of control based on an optimum combination of factors, rather than at one fixed or programmed value of the variables, has long been discussed theoretically—but the year ended with the introduction of an "Optimal Controller" which can maintain the operating point of a process at an optimum value with respect to a secondary variable. This development opens entire new areas of control and is, like the systems concept, based on knowledge of the inter-action of the elements within the system. Its success will depend on how well these analytical data are developed—but the task of analysis for optimal control of one unit in a system is obviously less exacting than systems engineering of an entire system. Perhaps optimal control can be called the systems engineering of one unit operation, as opposed to the systems engineering of a system with many units.

It is of interest to note that both systems engineering and optimal control—the two most exciting concepts of 1956—are essentially analytical techniques whose success will depend on how rapidly and how well all the system and its elements can be analyzed for use by those who wish to control the system more efficiently.

A third concept that had great impact in 1956 was that of digital automation, which means the use of digital techniques in making automatic decisions and efforts. The basic techniques of counting and computing via binary, trinary or special coded systems (as opposed to the arithmetically complicated conventional decimal techniques) emerged in 1956 as the most efficient way of multiplexing, gaging dimensions, making logical decisions, performing machine control, and computing.

Hardware

The "hardware" news of 1956 includes (1) gaseous phase chromatography, (2) recording microbalances, (3) combination valve actuators, (4) data processors, (5) analog computers, (6) digital computers, and (7) analog-to-digital converters.

Gas chromatography is being hailed as one of the most important analytical instrument developments in a decade because the simple instrument can perform both qualitative and quantitative analyses of materials whose boiling points are below 250°C. Both elution-partition (gas sample and liquid column) and absorption-displacement (gas sample and solid column) are used in commercial instruments, of which 1000 were sold in 1956, according to industry reports.

A second newsworthy event in analytical circles was the recording microbalance disclosed by Dr. A. Peterson of the Mellon Institute of Industrial Research. The Peterson technique involves the use of a differential

transformer to sense the beam displacement, and resulted in a 10,000-fold sensitivity increase—permitting comparative weighings of the order of 0.01 microgram *plus* automatic recording and reduced sensitivity to vibration.

Several new combination valve actuators were introduced in 1956 to take advantage of the high speed of available electronic controllers and to remove the previously existing response limitation associated with valve positioning. These actuators included electropneumatic, electrohydraulic, and pneumohydraulic actuators, whose combinations of techniques now make possible optimum use of available power sources to achieve the desired response characteristics. This was the big valve news of 1956.

Data processors reached the "acceptance" stage in 1956, and several complete lines of automatic data receivers, manipulators and digital recorders reached the debugged on-line stage. Refinements such as rapid pinboard-type setup and automatic checking were added in 1956.

The analog computer is the *equipment* which makes possible "systems analysis"—if the system units are defined or definable. Any plant can perform its own systems engineering if it learns the techniques of analog simulation and analog computation. Management is awakening to the possibilities of analog computation, and the computer manufacturers are ready with a complete line of equipments of any size, including refinements such as automatic setup from typewriter-type inputs, automatic checking features, arbitrary function generators, etc. These refinements were the analog computer news of 1956.

The digital computer news of 1956 included the introduction of several general-purpose digital computers featuring small size, high flexibility, and adaptability to a host of engineering and scientific problems. Of particular importance was the disclosure of random-access memories of multi-million-bit capacity, based on novel arrangements of tapes, drums, and discs, to achieve random access to any of millions of bits of data within a second or less.

Tying the analog and digital fields together was the introduction of a beautiful array of analog-to-digital converters, permitting the conversion of analog data into digital data at rates from seconds to microseconds, using codes of many different types, and with outputs tailored to the needs of various industries.

Automation Investigation No. 2

For the second time, a Congressional investigating committee has investigated the automation industry. For three days (Dec. 12-14), representatives of our industry told the committee that:

1. Automation is essential to the economy.
2. Automation is essential to national defense.
3. More students should study automation or other technical subjects in vocational schools.
4. More students should study automation or other technical subjects in high schools.
5. More students should study automation or other technical subjects in college.
6. More and better teachers and courses are needed in vocational schools.
7. More and better teachers and courses are needed in high schools.
8. More and better teachers and courses are needed in college.
9. Automation increases productivity.
10. Automation increases the level of human activity, dignity, motivation, morals, etc.
11. Automation equipment manufacturers need tax relief.

Amen! But substitute the words mathematics, engineering, research, chemistry, physics, industrial arts, machine tools, medicine, etc., etc., for the word automation and the statements are equally valid. Our view of the testimony is that "we love ourselves."

But the public will not read the excellent testimonials to our own importance. They will hear only that Congress has automation under continuous investigation, along with big business, big labor, and subversives. If any of the testimony finds its way into mass-circulation media, it will probably be the comment by union leader George Meany (AFL-CIO) that job opportunities are the responsibility of American management, or the comment by one industry representative that "the concentration of automation in a particular industry may constitute serious economic or social problems."

Most attention was given to two problems commonly associated with automation—economics and education. With regard to the economic implications of automation we repeat a comment from our reaction to the first Congressional investigation of automation, held October 14-18, 1955: "We waited in vain for somebody to point out that the economic stability of the nation depends on factors other than automation . . . the result of this investigation will be that more people will believe the myth that automation can create jobs and an expanding economy—or the opposite but equally mythical premise that automation can destroy jobs and cause unemployment. Both of these myths turn attention away from the true heart of the investigation—which is the question of how best to maintain our expanding economy." We are still waiting.

The problem of labor displacement or unemployment is basically that of finding a new job. If jobs are available, the problem is personal—but not national; if jobs are not available, the problem is both personal and national—*but the problem is one of job availability.*

What then makes for job availability? The answer is an *expanding economy,* which leads to the key question —what makes for an expanding economy?

Not being economists, your editors do not presume to tell either our readers or our Congressmen just how credit, prices, wages, interest rates, federal expenditures, etc., etc., influence the economic health of a country. But these are the matters that need investigation if the

intent is an honest analysis of our economic state.

The first Congressional investigation, having been instigated by labor, was top-heavy with labor experts who said, in effect, "watch out for automation—it can be beneficial or very harmful."

The second Congressional investigation, promoted by the ISA, was packed with industry spokesmen who said, in effect, "automation is simply the backbone of the nation." Had our industry done a systems engineering job on the subject, it would have come before this Congressional committee loaded with engineering data about all the factors that establish the economic health of the economy (only one of which—and probably a secondary factor at that—is productivity). We talk a lot about systems engineering—but we apply little of it within our own field and, apparently, even less outside of it.

Automation and Education

The situation viewed with the most alarm at the Congressional hearings had to do with education. It can be argued that as long as our populace will tolerate gradual deterioration of its school facilities, it will get that deterioration. Our industry spokesmen were not the first to tell some Congressmen about the sad state of our schools.

But even though federal aid to education is bogged down in politics, much can be done at the local level—and a program is underway in Pittsburgh, Pennsylvania, the nucleus of many other national movements in the field of automation, to attack this situation. It is described here as a constructive approach to the education problem, and one that can be followed by any group of engineers, any locality, any school system.

A Proposal for a High-School Course In Automation and Industrial Technology

Presentation made by Milton H. Aronson, Editor, *Instruments & Automation*, to the Board Committee on Education, Board of Public Education, Pittsburgh, Pa., Feb. 4, 1957.

Ladies and Gentlemen of the Board of Public Education of the School District of Pittsburgh:

It is with a sense of pride and an awareness of participating in what may be a historic development that I come before you today to propose a unique and progressive plan for the high schools of Pittsburgh. I speak as chairman of a committee which has, for the past six months, been working on both the broad objectives and specific details for this plan, in close cooperation with school officials.

The committee of consultants, for which I am now speaking, and which has several members here for your questioning, is made up primarily of engineers and scientists representing the various types of industry located in the tri-state Pittsburgh industrial region. Organized labor also is represented on the committee.

Trends in Technical Education

It is apparent to all that modern civilization is based firmly on science and engineering, and that the sciences and related engineering skills are rapidly expanding fields. Monthly developments are reported by the hundreds in the technical press—entire new fields of endeavor now evolve within the short space of a year or two. Progress in science and engineering has been such that new fields such as computers, nucleonics, tracer chemistry, data handling, servomechanisms and many others all need trained specialists in large numbers—in addition to the normal needs of industry and research. However, our supply of technically trained persons is woefully inadequate, not only for present needs but also for the mounting needs of the future. How should this serious national problem be attacked?

The Place to Start

National debates have raged with great intensity on the subjects of federal aid to legislation, industrial raids on teaching staffs, loans of part time teachers to schools by industry, etc., etc.—but little except talk has been done, at any level. It appears to this committee of consultants that the starting point, the heart of the entire problem, is the high school. *Here* is where the imagination of the student must be captured and his first indoctrination to technical education begin. That this is not occurring as it should is proved by the fact that progressively smaller percentages of high-school students are taking math-science courses, and by the obvious failure of the average high-school system to keep its laboratory facilities abreast of the new technologies of our times.

For these reasons, this committee of consultants proposes a high-school course in the new technologies, a course in automation, which will be essentially a laboratory-classroom course in instrumentation, electronics, and industrial chemistry. In this course the student will measure and control the intensity of sound, the speed of motion, the flow of liquid, the temperature of metal, the pressure of gas, the strength of material. The objectives of the course are:

1. To increase the interest of students in modern technology, including instrumentation, industrial chemistry, and electronics.
2. To induce students to go on to college to become superior workers in the fields of engineering and science of their choice.
3. To train students for important positions as either technicians, junior engineers, senior engineers, or scientists, depending on their inclinations, opportunities, and abilities.

These three aspirations and objectives have equal weight and importance. They are all capable of realization because the proposed curriculum contains the funda-

mentals of the new technologies which are now the roots of both engineering and scientific work.

The Course Content

The committee of consultants feels that the basic objectives can be realized by a course which contains the fundamentals of measurement, control, electronics, and industrial chemistry. They have agreed also that these fundamental subjects are so basic and so important that they are necessary to technical work of almost any type. Hence the proposed course is a fundamental technical course in technologies which are both basic and of growing importance. The course content itself is given in the brochure prepared by the committee of consultants who, meeting once a week for six months with officials of the Pittsburgh School System, have outlined a full 3-year course in automation, with specialties in instrumentation, industrial chemistry and electronics.

It is expected that the student electing the course will devote two hours per day in his sophomore, junior, and senior years to these subjects. There will be no interference with his normal high-school curriculum. The student, if qualified, will meet all college-entrance requirements. Scheduling problems have been worked out in cooperation with school officials.

The problems tackled by the consulting committee included:

1. The preparation of a course that would both arouse the interest of students and educate them in important new technologies.
2. The procurement of adequate facilities and equipment for the course.
3. The procurement and indoctrination of suitable teachers for the course.

Problem 1 was attacked by developing the proposed curriculum, given here.

Problem 2 was attacked by visiting the several high schools that had available space, examining their laboratory, classroom and library facilities, and evaluating the location and environment of the school. A recommendation has been made by the committee to the Superintendent of Schools that the course be started in Allegheny High School. Qualified students from other schools may select this course, which will begin at the 12th grade level in its first year (1957), the 11th and 12th grades in 1958, and will become a full 3-year curriculum in later years.

The third problem—facilities and teacher procurement—was attacked by investigating possible sources for grants of both equipment and money on a local and national scale. An ambitious plan is underway to enlist the support of every technical society in the Pittsburgh area, under the chairmanship of a nationally known Pittsburgher, in attaining the three basic objectives. Equipment manufacturers already have pledged much equipment for the laboratory. Several possible teachers already have been approached, and indoctrination courses have been investigated for these teachers; such courses are available.

This approach to the problem of technical education in the high schools is unique in several respects—it is the first to give such emphasis to the subjects of measurement and control at the high-school level. These subjects are so fundamental that they could well serve as a base for an expanded technical education program extending into related fields. Further, the plan to enlist the support of an entire industrial community through cooperative action of its many technical societies can have important implications for the future.

The minimum objective for the first year is one class, one laboratory, and one teacher indoctrinated in the new technologies; the ultimate goal may well be a technical high school for Pittsburgh or similar programs for other schools. Present plans, of course, cover only the first year's objective.

Credit for the tremendous amount of work, as well as for the courage and vision required to plan this program with its many details, accrues to the committee of consultants and to the officials of the Pittsburgh School System who have worked with us on this project. This group feels that the proposed program is both practical, realizable, and important. Its importance stems from the fact that our schools, our teachers, our students need new approaches to the new technologies of our times. The proposed program aims at teaching these new technologies, and at enlisting the support of our entire regional community in carrying out its objectives.

Pittsburgh, Pennsylvania has been the nucleus for many, if not most, of the important national developments in instrumentation and automation. It was the first—in 1928—to give birth to a national publication devoted to industrial instrumentation—*Instruments, the Magazine of Measurement and Control*, now *Instruments & Automation*. It was the first—in 1939—to organize a technical society devoted to instrumentation, which local group formed the core for today's Instrument Society of America. It will, we hope, be the first to offer a full high-school curriculum devoted to automation and the modern industrial technologies.

It is fitting to conclude this presentation and proposal with a list of the men who have worked out the plan.

Milton H. Aronson, Chairman. Editor, *I&A*.

Lester R. Driskell, Principal Instrument Engineer, Blaw-Knox Company, Chemical Plants Division

Dominic Dornetto, International Rep., UAW-CIO.

James H. Greenwood, Chief Engineer, WCAE, Inc.

Joseph Senyk, Head, Instrument Section, Engineering Division, Manufacturing Department, Gulf Oil Corp.

Dr. Ernest O. Ohsol, Director Research and Development, Pittsburgh Coke & Chemical Company

Dr. Axel Peterson, Head, Department of Instrumentation, Mellon Institute of Industrial Research

George Karnofsky, Assistant Technical Director, Blaw-Knox Company, Chemical Plants Division

Thomas C. Kenney, Chief Engineer, Station KDKA

George W. Walther, Manager Chemical Production, Pittsburgh Coke & Chemical Company

Equal credit is due to the officials of the School System who have given their time to work out the details for the proposed course with the Committee of Consultants:

Dr. Earl A. Dimmick, Superintendent of Schools

Charles F. Hoffmaster, Director of Vocational & Industrial Arts Education

Dr. Evan Ingram, Associate Supt., Secondary Education.

Oscar Schwarm, Dir., Guidance and Child Accounting
Eugene Peckman, Senior Supervisor, Science and Math.
Harold B. Black, Assistant Director, Vocational & Industrial Arts Education
John H. Kudlik, Assistant Director, Vocational & Industrial Arts Education.
Dr. John P. Schaefer, Director, Public Relations

Automation Curriculum

These 25 units represent a full 3-year course in all specialties. Each student will receive 4 or 6 units in his senior year, 4 units in his junior year, and 4 units in his sophomore year (1 unit = 1 semester hour = 1 hour per day per semester).

Unit I—Fundamentals

a. Units—°F, °C, psig, psia, etc.
b. Pneumatics, hydraulics
c. Mathematics and slide rules
d. Electrical fundamentals (ohm's law, series, parallel and bridge circuits)
e. Basic chemical processes
f. Safety

Unit II—Practical Skills

a. Piping
b. Soldering and Welding
c. Wiring (relays)
d. Sheet metal fabrication
e. Chassis preparation
f. Blueprints and flow sheets
g. Glassblowing

Unit III—Basic Electronics

a. Signals and simple circuits
b. Vacuum tubes and gas tubes
c. Rectification and power supplies
d. Amplifier circuits
e. Oscillator circuits
f. Signal shaping circuits

Unit IV—Test Instruments

a. Dead weight checks
b. Manometers
c. Voltmeters—ammeters—ohmmeters
d. Tube checkers
e. Recorders—inking, oscillographs, tape
f. Amplifier—ac, dc, low-level
g. Power Supplies, regulated, unregulated
h. Analytical balance and burette

Unit V—Thermometry & Pyrometry

a. Mercury in glass
b. Bimetal
c. Pressure-activated (gas, liquid, vapor filled)
d. Thermocouples
e. Potentiometers
f. Wheatstone Bridges
g. Resistance Elements
h. Thermistors
i. Optical Pyrometer
j. Radiation Pyrometer

Unit VI—Pressure

a. Bourdon gages
b. Bellows gages
c. Diaphragm gages
d. Differential gages
e. Pickups—load cells, strain gages, diff-transf, capacitance.
f. Telemetering

Unit VII—Flow

a. Orifice
b. Pitot
c. Rotameter
d. Venturi
e. Turbine
f. Mass flow
g. Positive displacement

Unit VIII—Level

a. Float Operated Instruments
b. Gage Glasses
c. Tank Gaging Systems

Unit IX—Advanced Electronics
Unit X—Analytical Instruments
Unit XI—Radioactivity Instruments
Unit XII—Dimensional Gaging and Inspection
Unit XIII—Data Handling
Unit XIV—Valves and Piping
Unit XV—Controllers
Unit XVI—The New Technologies
Unit XVII—Electronics Specialty
Unit XVIII—Process Specialty
Unit XIX—Iron & Steel Specialty
Unit XX—Industrial Chemistry
Unit XXI—Machine Tool Field
Unit XXII—Inspection Specialty
Unit XXIII—Drafting Specialty
Unit XXIV—Metallurgy Specialty
Unit XXV—Mining Specialty

Dear D. R.*:

Your editors must be in a mood this month—because we've chosen to debunk everything from Congressional committees to computers. But too many persons in our field seem to be going around with swelled heads lately, so we decided to look at ourselves in a mirror and apply a little self-criticism via a few articles ("Myths of Automation" by James Bright, and "Uncommon Uses for Common Digital Computers" by Martin Klein) and an editorial ("Congressional Investigation No. 2").

No doubt these will bring another flood of reader response (no, we will not say feedback) similar to that which you will find in the "Letters to the Editor" columns this month. This exchange of correspondence was prompted by our November editorial "The Effect of Automation on the Economy." The reaction runs the entire gamut of human emotion and reason. Some of our more dedicated industry spokesmen think it is heresy to even suggest that our industry is not the sole bulwark of national prosperity and safety. But, as the only publication which has for 30 years been fighting tooth and nail for industry recognition—and this includes the time when the industry was small and the fight really tough—we feel that we have a responsibility as well as a right to point out that (1) the recognition we are now getting from the general public, the press, the government, and neophyte editors and writers leaves a lot to be desired, and (2) our industry missed a golden opportunity to "system engineer" some pressing national problems in front of a Congressional committee.

**Dear Reader*

Of course there is a lot more than "debunk" in your issue this month. First, there are two exclusive disclosures for you—the General-Purpose Integrator on pages 254-255 is the first such device designed to accept *any* analog signal and perform the specific integration needed for a host of test purposes, and (2) the new developments in production techniques for area meters on pages 256-257 will revive interest in this phase of flow instrumentation.

Second, the article "Electronic Counting" (No. 16 in your Digital Automation series) shows the power of modern counting technique in basic instrumentation. We placed this article immediately in front of the "General-Purpose Integrator" article because the two, combined, take you right up to the frontier of counting techniques.

Finally, the article "Basic Analysis Methods for Nonlinear Control Systems" is a survey-type article which not only describes the features of phase-plane and describing-function methods of system analysis, but also describes numerical, step-by-step, graphical, and equivalent techniques for system analysis. The bibliography in this article (page 267) is especially important because it covers a good part of the entire literature of the field of "systems engineering."

You will also find some provocative discussions in the *Simulation Council Newsletter* this month on the subject of "What's Next in Analog Computers." This is one field you are going to find in your future.

Hope this finds you (reading) well and happy this month.

Cordially,
Milt and the Editors

Where do you belong in

Computer Circuit Design Engineers plan electronic circuitry for advanced airborne analog and digital computers . . . design linear and pulse circuits employing transistors, tubes, magnetic devices. Opportunities also exist in airborne power supply design, or to develop new techniques for marginally checking computer performance. *Do you belong on this team?*

Computer Logical Design Engineers determine the systems outline of a computer and its inter-connection with external equipment. Close liaison is maintained with mathematical support, circuit design, packaging and test engineers. Computer speed, memory size, configuration and arithmetic structure are tailored to requirements of weapons systems. *Do you belong on this team?*

Systems Evaluation Engineers test and evaluate electronic analog and transistorized digital computer systems design for aircraft; evaluate new systems and improvements to insure compliance with specifications and Air Force requirements. Other assignments: tie-in testing of peripheral equipment, liaison with design, development and field engineering. *Do you belong on this team?*

Harry Branning (center): B.S.E.E. 1950, Syracuse. Design Engineer in circuit design, 1951; October, 1954, promoted to Associate Engineer; April, 1956, promoted to Staff Engineer, Systems Planning. In June, 1956, appointed Project Engineer and Manager of the 110 Computer Circuit Design Department; discussing the performance and packaging details of a transistorized read amplifier.

William Dunn (standing): M.E. 1950, M.S.E.E. 1952, Stevens Institute. Technical Engineer, 1955; April, 1956, promoted to Associate Engineer; August, 1956, transferred to Development Engineering in charge of Logical Design for digital computers in advanced weapons systems; here discussing Boolean Algebra method of optimizing the logical design of an airborne digital computer.

Eli Wood (left): B.S.E.E. 1950, Connecticut. IBM Customer Engineer, July, 1950; September, 1952, transferred to ACL Field Engineering. February, 1954, in charge of Field Engineering at Hunter AFB; May, 1955, Associate Engineer; appointed Project Engineer, Manager of Systems Evaluation in August, 1956; here investigating a problem in radar data presentation set evaluation testing.

The brief records of the men cited above indicate only a few of the exciting activities right now in IBM Military Products. This division, organized 18 months ago, has grown enormously. A small-company atmosphere prevails. Men work in small teams . . . individual contributions are instantly recognized. Promotions occur frequently.

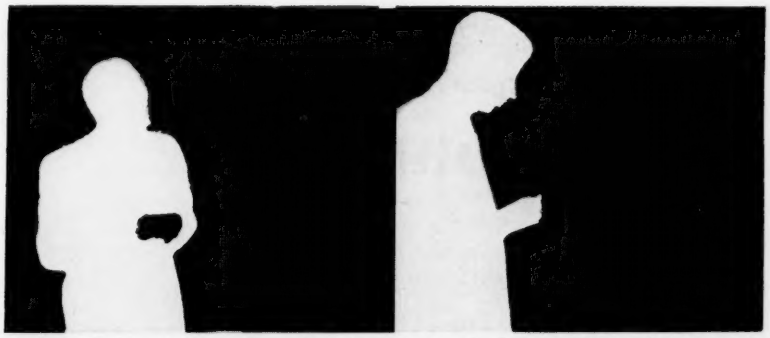
As a member of IBM Military Products, you'll enjoy physical surroundings and equipment second to none. Educational programs at IBM expense lead to advanced degrees. Salaries and benefits are excellent. Stability is guaranteed by IBM's history of consistent achievement—underlined by the fact that the rate of turnover at IBM is only one-sixth the national average.

Throughout the length and breadth of the United States IBM has built modern plants and laboratories. This map points out the various locations where you might live as an IBM em-

DATA PROCESSING
ELECTRIC TYPEWRITERS
TIME EQUIPMENT
MILITARY PRODUCTS

IBM MILITARY PRODUCTS

IBM Military Products?



Systems Engineers oversee the engineering support provided by the Systems Coordination and Specification Group to the factory on the AN/ASB-4 Bombing-Navigational System. Air Force requirements are analyzed and the resulting engineering changes evaluated to determine effect on system performance and accuracy. Mathematical error analyses are run. *Do you belong on this team?*

Systems Analysts anticipate performance and recommend design criteria before and during development of equipment. Later, they compare dynamic performance accuracy and reliability characteristics with what has been anticipated. Other assignments include Digital Computer Systems Engineering, Input-Output and Analog-Digital Conversion Engineering. *Do you belong on this team?*

Quentin Marble (left): B.S.M.E. 1951, Syracuse. Joined IBM in 1951; promoted to Design Engineer in 1952; May, 1955, promoted to Associate Engineer, and then to Project Engineer, Manager of the Systems Coordination and Specification Group, Production Engineering Department, in February, 1956; shown here describing a unique cooling design to a new employee in his group.

Monroe Dickinson (left): B.S.E.E. 1952, W.P.I.; M.S.E.E. 1954, M.I.T. Technical Engineer in analog and alternate computer techniques for weapons systems, 1952; Associate Engineer responsible for systems design and analysis, 1954; December, 1955, Staff Engineer, responsible for research planning; here reviewing set-up on laboratory analog computer of a sampled data control problem.

Exceptional career opportunities are now open in IBM Military Products for E.E.'s, M.E.'s, physicists, and mathematicians, in the following fields:

SYSTEMS PLANNING AND ANALYSIS
DIGITAL AND ANALOG SYSTEMS
INERTIAL GUIDANCE
SERVO-MECHANISMS
ELECTRONICS
MECHANICAL DESIGN
ELECTRONIC PACKAGING
PROGRAMMING
FIELD ENGINEERING
RELIABILITY
COMPONENTS
PHYSICS
MATHEMATICS
HUMAN ENGINEERING
INSTALLATION
CIRCUIT DEVELOPMENT
POWER SUPPLIES
TRANSISTORS
HEAT TRANSFER
OPTICS
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TECHNICAL PUBLICATIONS

ployee. IBM Military Products include the Airborne Computer Laboratories located in Owego, N. Y., and the Project SAGE installations directed from Kingston, New York.

Here is a real ground-floor opportunity that you can't afford to overlook. Without exaggeration, your potential in this dynamic young field of electronic computers is virtually unlimited. Get all the facts. Write, outlining your background and interests to:

R. A. Whitehorne
Manager of Engineering Recruitment, Dept. 3602
International Business Machines Corp.
590 Madison Ave., New York 22, N. Y.

Electronic Counting

Many digital problems are solvable simply by counting techniques plus timing accessories. Various flexible modes of counting are now available, including binary counting, decade counting, preset counting, gated carry counting, digital count totalizing, events-per-unit-time counting, X/Y counting, analog time counting, and ring counting. This discussion starts with the basic 2-state counting element and concludes with a generalized technique for feedback counting.

MARTIN L. KLEIN
FRANK K. WILLIAMS
HARRY C. MORGAN
Rocketdyne Div.,
North American Aviation, Inc.

COUNTING is nearly as old as thought itself; it is the indispensable tool of any civilization which demands a numbering system, as was discussed in Chapter 2 on code arithmetic.

Counting is used in many different ways in digital techniques, and a host of measurement and control problems are directly solvable by counting techniques and counting circuitry, which field has become an established and important field of endeavor. There are many familiar mechanical aids to counting, including hand tallying of which perhaps the oldest is the Oriental abacus whose initial use undoubtedly was as a tally register. A familiar mechanical counter is the automobile odometer, which translates the revolutions of a shaft into highway miles. No time measurement is involved in this type of counting.

Time measurement is involved in counting when it is necessary to specify the time at which a certain count of items exists, or when we attempt to count the number of items or objects which occur per unit time. It is obvious that we can specify this latter count in terms of the analog time measured between occurrences. Note that we can classify digital counting in three ways:

1. **Digital total counts (no time measurement involved).**
2. **Digital count of events or objects per unit time.**
3. **A time interval (analog) between events or objects.**

We will concern ourselves here with modern electronic methods of counting; vacuum-tube circuitry will be described in detail (as in Chapter 5). Magnetic core techniques and transisters can be and are being used to perform the functions we will describe in terms of vacuum-tube circuits. However, the principles are similar.

When the physical events to be counted are in electrical form, such as an alternating current or a pulse series, simple electronic-counter input coupling is required. However, transducers are required to translate nonelectrical events into appropriate form for electronic counting. For example, a count of objects can be obtained by having the objects intercept a light beam which is incident upon a photoelectric cell, thus translating the object passage into an electrical signal. Any form of electromagnetic radiation can be used similarly to effect the translation of the digital events to be counted into electrical form. There are many transducers commercially available, a few of which will be illustrated in a later chapter on transducers. Special mention will be made (in another chapter) of transducers which translate variables such as fluid flow directly into digital electrical signals.

The Basic Electronic Counting Element

Table 5-1 in Chapter 5 lists several of the new electronic tubes which make convenient decimal counting elements for certain applications. However, the more general techniques are based on binary numbers and use electronic circuits capable of two states only, such as the bistable multivibrator or flip-flop described in Chapter 5.

Fig. 16-1 shows the circuit of such a flip-flop, with numbered output and input connections so that the simple symbol shown below the actual circuit can be used in complex assemblies of flip-flops, resulting in a simple circuit convention for system design. As has been described, this circuit can have one of two states only: if one half of the tube is conducting, the other half is nonconducting. If the left half of the tube is conducting,

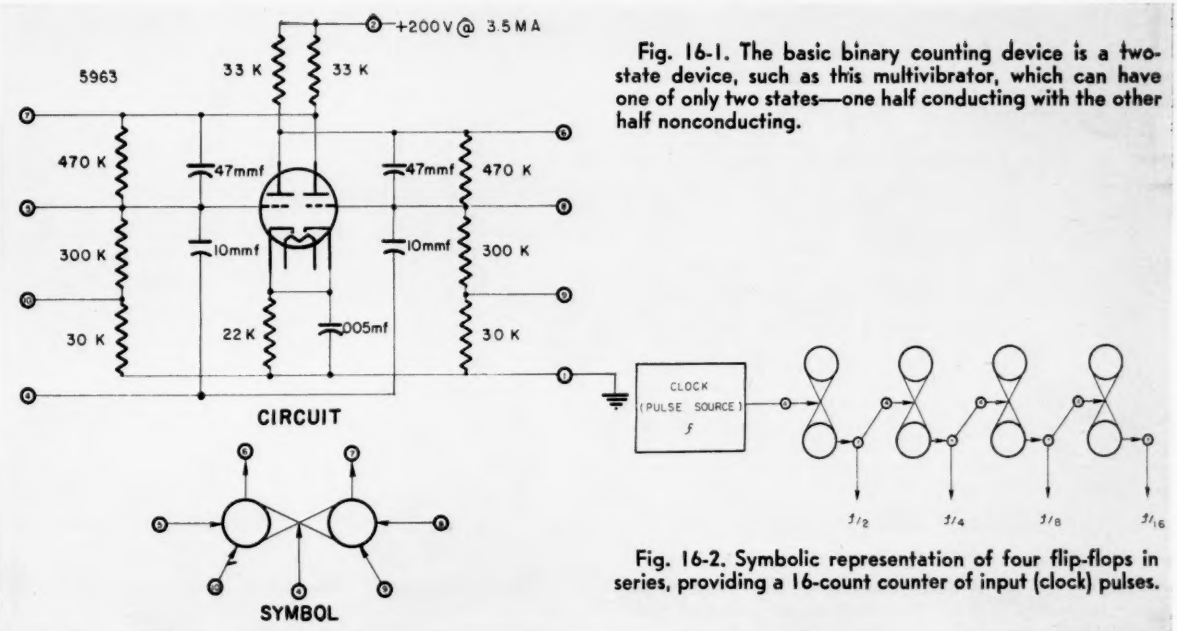

Fig. 16-1. The basic binary counting device is a two-state device, such as this multivibrator, which can have one of only two states—one half conducting with the other half nonconducting.

Fig. 16-2. Symbolic representation of four flip-flops in series, providing a 16-count counter of input (clock) pulses.

output 6 is low, the right half of the tube is nonconducting, and its output (7) is a high voltage with respect to pin 1.

Under these conditions a negative voltage pulse applied to input 5 will cause the left half of the tube to become nonconducting, and the right half to conduct. This is the reverse of the former state, and output 6 now will be high and output 7 low.

If a succession of negative pulses is applied to input 4, the pulses will reach both grids via the 10-uuf coupling capacitors. However, only the conducting half of the twin triode is able to respond to these negative signals because the nonconducting half cannot react to a negative signal on the grid. The circuit will respond to each negative input pulse by reversal of left and right tube states. This results in a negative fall of output 7 or output 6 *once for every two negative input pulses to input* 4. As there is one output for every two inputs, the circuit can be said to be counting by two's or dividing by two.

The circuit of Fig. 16-1 provides for different inputs for initiating the flip-flop action. Inputs 5 and 8 provide direct connection for a low-current signal; input 4 provides a common coupling for a-c negative signals to either control grid. Diode isolation between both grids and the 10-uuf capacitors is required in some critical circuits where large positive pulses are present.

Inputs 9 and 10 provide *reset* and *preset* connections for convenient parallel connections which prevent interaction between flip-flops.

Cascading the Basic Counting Elements

Fig. 16-2 illustrates how four flip-flops of the type shown in Fig. 16-1 are connected in a cascade circuit. A source of negative pulses, termed a *clock*, connects to the common input (4) of the first flip-flop on the left. Output 7 of this flip-flop emits one negative-going voltage pulse for each two input pulses to pin 4. The input pulse frequency is therefore divided by 2. If this output is connected to pin 4 of the second flip-flop, the second flip-flop divides by two, resulting in ¼ the clock frequency. There is no limit to the number of flip-flops that can be cascaded in this fashion.

Counting With Cascaded Flip-Flops

A flip-flop is said to be in the *zero state* when its output (pin 7) is at its low value (about 100 volts); it is said to be in the *one state* when the output rises to its high value (200 volts).

If we connect voltage indicators to each of the four outputs 7, we can read the binary count standing in the counter. It is convenient to connect small neon glow tubes between the outputs and an appropriate fixed voltage so that when the voltage of an output is low, the glow lamp is dark. This indicates a zero. When the output pin is high, the glow lamp is turned on to indicate a 1. It is simplest to use the unused output plate (pin 6 in Fig. 16-1), and to connect the glow lamp between pin 6 and the 200-volt B supply. Therefore, when output 7 is low to indicate a 1, pin 6 is automatically high and the glow lamp is dark. If output 7 is high, indicating 1, pin 6 is low and the glow lamp is turned on.

If all of the output voltages (pins 7) are low when the clock starts counting, we say that the flip-flops (or binary counters) are all in the zero state. We can write this as binary number 0000 with the left flip-flop corresponding to the right-most or least-significant zero. After the clock emits one pulse, the first counter output

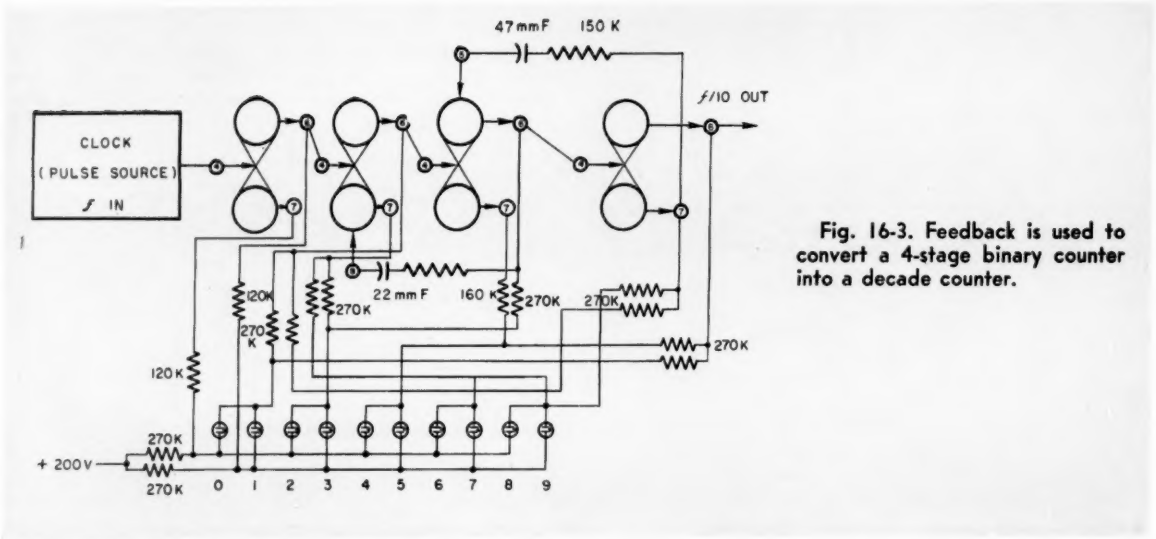

Fig. 16-3. Feedback is used to convert a 4-stage binary counter into a decade counter.

voltage goes up to plus 200 volts. The binary count now reads 0001. After the clock emits a second pulse, the left counter returns to its original zero state but passes a negative *carry* pulse to input 4 of the second counter; the binary count standing in the counters is now 0010. With each successive pulse, the counters show the increasing binary count in exact binary-count fashion: 0011, 0100, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111. The sixteenth pulse resets all of the counters to 0000.

This simple binary counter indicates (in binary code) the number of pulses put into it via a row of neon glow lamps. The first practical electronic counters were made in this way about 5 years ago, and were used extensively in early nuclear work for counting the number of ionizing particles emitted by radioactive elements. Binary counters are still used extensively; however, conversion of the resulting binary number to the more convenient decimal number by hand addition was cumbersome. Therefore, about ten years ago a binary counter which gave a decimal-number readout began to be used.

The Decade Counter

Fig. 16-3 shows a four-stage cascaded binary counter in which certain flip-flop outputs are fed back to previous flip-flops in such a way that the circuit counts from 0 to 9. The two feedback loops shown force the count so that the pulse output of the fourth flip-flop is one tenth that of the input clock. Pulse feedback is practical because there is a brief delay between the input pulse and the time that an output pulse appears: the feedback occurs within this interval.

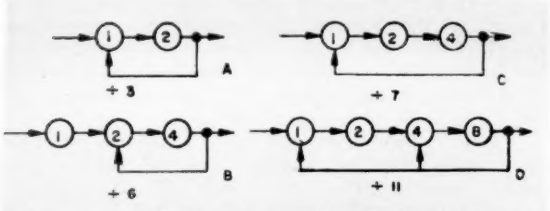

Fig. 16-4. Method for determining the feedback paths required in order to count to any given number.

The operation of this system can be considered in terms of binary addition. The two feedback pulses are put in at the f/2 and f/4 points, so they can be considered as adding 0010 and 0100 to the counter bank. Thus, by binary addition:

0010	decimal 2, supplied by lower feedback loop
0100	decimal 4, supplied by upper feedback loop
1010	decimal 10, pulses supplied to first counter, time serially
10000	decimal 16 (with output carry pulse).

The binary 1 in the fifth place to the left is the output or carry pulse that enters into a second or *tens decade* while the *ones decade* resets on the tenth input to 0000.

By use of appropriate feedback networks, a four-cascade counter can be made to count up to any number up to sixteen. Fig. 16-4 shows a simple decimal-number method for determining the feedback paths required. This technique for telling exactly what end count will be with any circuit is to write the numbers 1, 2, 4, 8, . . . in the schematic and subtract the numbers to which feedback is applied from total count.

In example A, two binaries without feedback count by 4's. Subtract 1 from 4 and the result is a count-by-3 circuit.

In example B, 3 binaries without feedback count by 8. Subtract 2 from 8; thus the circuit is a count-by-6.

In example C, the 3 binaries would count by 8 without feedback. Subtract 1 from 8; therefore, the circuit is count-by-7 circuit.

In example D, the four binaries would count by 16 without feedback. With feedback as shown, subtract 5 from 16, and the circuit divides by 11.

It is desirable to be able to read the number in a feedback decade as a decimal number from 0 to 9. The lower half of Fig. 16-3 shows how a matrix of resistors and neon (Ne-2) glow lamps can be set up to cause the glow lamps to indicate the count in the desired sequence. These elements are arranged in "AND" gating circuits in a similiar fashion to the neon-glow-lamp matrix technique described in Chapter 5.

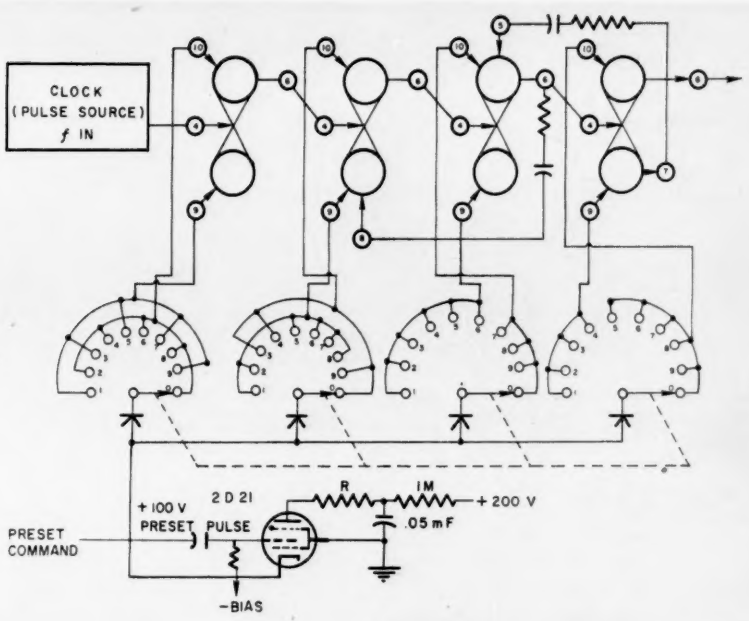

Fig. 16-5. Use of binary wired switches to preset a counter using the complement-of-the-count technique.

Preset Counters

It often is desired to preset a counter to a certain number, at which time an output pulse is obtained which can be used, for example, by control circuitry for a process. A technique using a diode trunking matrix and binary-wired preset switch was described in Chapter 15 (in the Variable Interval Automation Controller or VIAC).

Fig. 16-5 shows another way in which cascaded counters can be made to count to a preset count. This method is to preset into the counter bank, before counting begins, the *complement of the desired count.* (This is a specific case of feedback as described in the last section.) The counter then counts from this preset count up to the full count and resets to the zero count. For example, if we wish to preset the counter so that it gives an output or carry pulse after 6 input pulses, we preset 4 (the complement of 6) into the counter bank. Therefore, by binary addition:

0100	decimal 4, preset into counter bank,
0010	complement of 6 (10—6=4)
0010	decimal 2, supplied by lower feedback loop
0100	decimal 4, supplied by upper feedback loop
0110	decimal 6, time serial pulses supplied to first counter
10000	decimal 16, with output carry pulse

The upper half of Fig. 16-5 is identical to Fig. 16-3; the lower half shows a row of binary-wired *number preset switches.* These switches are wired in a reverse binary fashion so that the complement of the number is added in parallel to the counter bank. The preset number is not added to the counter bank until a positive voltage pulse is supplied to the grid of the thyratron preset tube. When the thyratron fires, it conducts heavily so that nearly 100 volts is supplied to the preset inputs (9 or 10) of the flip-flops. The RC network in the plate circuit of the thyratron drops the plate voltage (when the heavy plate current is drawn) below the voltage required to maintain the thyratron gas conduction. The thyratron thus is automatically turned off. The large positive pulse supplied to the preset inputs of the flip-flops insures that the desired complement number is added to the counter bank. (A small negative preset voltage can be used if a negative power supply is used.)

The advantage of the complement preset counter is twofold. First, the counter operates as a conventional feedback decade until an electronic preset command is given. This command also automatically clears any count remaining in the counter. Second, any number of binary-wired switches (or permanent configuration lines) can be connected to the same counter bank with diode isolation between preset lines to prevent interaction. Thus, it is possible to have a single counter count automatically in sequence as follows: 1 with an output carry; 1, 2, with output carry; 1, 2, 3, with output carry; 1, 2, 3, 4, with output carry; and so on up until it counts as a normal decade counter.

Another application of the preset complement counter is that the feedback decade loops can be removed and, by eliminating the preset switch but not the preset thyratron, permanent preset input 9 or 10 can be wired so that on the carry command from the counter-bank output 6 (rightmost flip-flop), the opposite output 7 will give a positive preset command to the thyratron, which presets the number 6 into the counter bank. Thus, by binary addition:

0110	decimal 6, number obtained by: 16—10=6 (a sixteens complement)
1010	decimal 10, time serial pulse supplied to first counter
10000	decimal 16, with output carry pulse

This last technique can be used in counter banks that are preset to count to any number; a centicade counter, which gives a carry pulse with the 100th input pulse and then resets is described next.

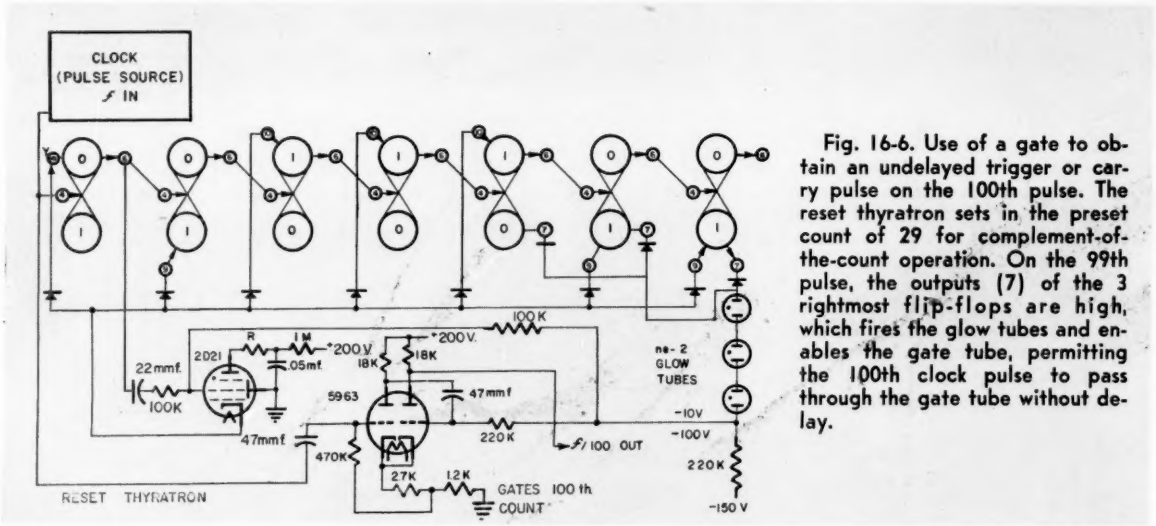

Fig. 16-6. Use of a gate to obtain an undelayed trigger or carry pulse on the 100th pulse. The reset thyratron sets in the preset count of 29 for complement-of-the-count operation. On the 99th pulse, the outputs (7) of the 3 rightmost flip-flops are high, which fires the glow tubes and enables the gate tube, permitting the 100th clock pulse to pass through the gate tube without delay.

Gated Carry Counters

The preset counter system described is used in Fig. 16-6 in a *centicade counter*. A normal centicade counter based on the techniques described would use the positive carry pulse obtained from output 7 of the rightmost counter to supply the reset command pulse to the reset thyratron circuit (connected as in Fig. 16-5)—according to the binary logic as follows:

0011100	decimal 28 (2^7 is 128, therefore 128—100=28)
1100100	decimal 100 (time serial pulses supplied to first counter)
10000000	decimal 128 (with normal negative carry pulse from output 6)

However, as the number of cascaded flip-flops increases, the summation of the delays between input and output of each counter stage can interfere with control-circuit operation, particularly in fast digital computers where counters are used. Therefore, in order to obtain a 100th carry pulse synchronized with the clock pulses, an "AND" gating arrangement is used to gate the 100th pulse. The complete circuit to do this is shown in Fig. 16-6. The vacuum-tube gate shown in the lower right of Fig. 16-6 requires —100 volts to remain closed, and —10 volts to open (for the 100th count). A triple-diode "AND" gate is connected to the three output 7's of the rightmost flip-flops so that all three must be high before the count gate is open. The Ne-2 glow tubes provide a d-c offset voltage without loss of voltage swing. It is desired to activate the "AND" gate on the 99th pulse; hence the counter is preset to the count of 99. By binary addition:

0011101	decimal 29 (preset number)
1100011	decimal 99 (time serial pulses supplied to first counter)
10000000	decimal 128 (which makes output 7's of last 3 flip-flops high)

When the 128 total is reached, the triple-diode "AND" gate supplies —10 volts to the vacuum-tube gate so that it is now open to pass clock pulses. The 100th pulse is now able to pass through the gate without delay as the centicade carry pulse. When the bias to the vacuum-tube gate is raised to —10 volts, this also raises the bias to the reset thyratron so that it can be triggered by the 100th pulse via phase inversion in the leftmost counter. This positive pulse causes the reset thyratron to conduct, thus presetting back into the centicade counter the preset count of 29. The counter is now ready to count again.

Decade Counters for Digital Count Totalizing

There are many situations where a *total count* of input pulses is desired in digital form. Fig. 16-7 shows a block diagram of a simple gated-input counter, which uses three decade counters (such as shown in Fig. 16-3) in decade cascade so as to obtain any total count from 0 to 999 counts. The decade on the left counts from 0 to 9, and the 10th pulse resets this decade to 0 and passes one carry pulse to the middle or tens decade. This middle decade indicates the 10's carry from the 1's decade from 00 to 90, and the tenth 10's carry passes a 100's carry pulse to the leftmost counter which totalizes the 100's carries. Additional decades can be added to indicate any required total count.

A pulse gate such as that in Fig. 16-6 could be used with a manual or electronic switch to open or close the gate with appropriate control voltages. It is usually more flexible to add a gate-control flip-flop in such a manner that the gate is controlled by a circuit similar to the way that the right flip-flop in Fig. 16-6 (without diode "AND" gates) is connected. Therefore, separate open and close commands can be applied to this gate-control flip-flop via inputs 9 and 10.

The conventional flip-flop requires a negative pulse with a certain amplitude and minimum rate-of-voltage change (*rise time*). Therefore, an X-input pulse shaper and amplifier may be required to prepare the input pulses for the decade counters.

In order to total a count, the gate is opened, which allows the input pulses to be counted and totaled by the bank of decade counters. The gate is closed when all of the desired counts are received.

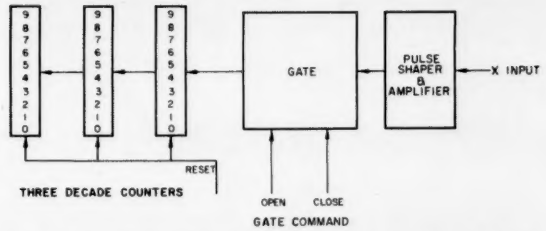

Fig. 16-7. Gated-input counter uses gate to control the time interval during which the digital counter is operative. The pulse shaper and amplifier is used to provide pulses of proper amplitude and rise time for reliable operation.

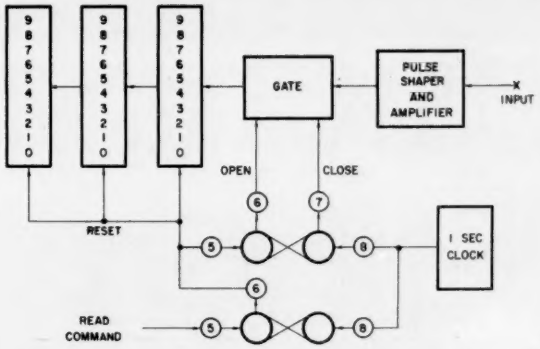

Fig. 16-8. Events-per-unit-time operation uses a clock to control the gate.

Events-Per-Unit-Time Operation

Another important use of an electronic counters is to measure a number of *Events Per Unit Time*, which is often termed EPUT operation.* This type of operation is required often, particularly to determine the frequency of an unknown a-c voltage. The usual time base used is one second. Fig. 16-8 shows how this is accomplished.

The upper half of Fig. 16-8 is identical to Fig. 16-7 except that a *reset-to-zero-count line* is added. In events-per-unit-time operation, it is required that the gate be opened for one second and then closed again. The bank of counter decades then will contain the number of pulses received during that 1-second interval.

The 1-second clock pulses are fed to input 8 of both clock flip-flops. When these clock pulses are negative, both flip-flops are held in the same state all of the time, with the gate being held closed. If a negative read command is applied to the lower clock flip-flop, it changes state so that the next clock pulse can change it back over again. When the lower flip-flop state is reversed by the clock pulse, a reset command is applied to the three decades and the upper control flip-flop is changed over so that the gate receives a d-c open command. The gate then is enabled so as to pass input pulses until the next 1-second clock pulse reaches input 8 of the upper control flip-flop, thus closing the gate again. If continuous frequency readings are required, a slow pulse clock can replace the manual read command.

The 1-second clock can be altered by appropriate switching circuitry so as to increase or decrease its rate in steps of ten, thus providing, in effect, a movable decimal point in the number indicated by the counter bank.

X/Y Count Operation

When the ratio of two frequencies is required, a circuit such as shown in Fig. 16-9 is used. This is essentially the same as Fig. 16-8 except that the 1-second clock of Fig. 16-7 is replaced by another input circuit which is identical to the X input. This means that the counter decades now totalize the number of X input pulses only for the time interval between Y input pulses. A slow read command clock can be provided for continuous measurement of the X/Y ratio.

Commercial counters, such as shown in Fig. 16-10, can provide the various counting modes discussed.

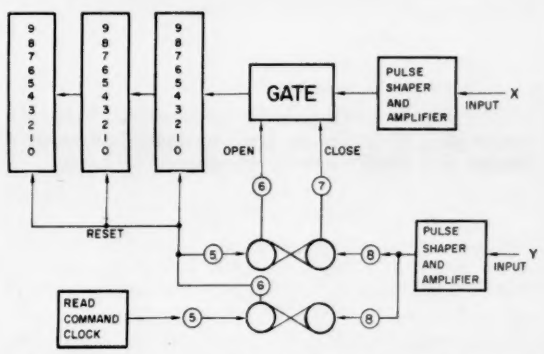

Fig. 16-9. X/Y operation is similar to events-per-unit-time operation except for the fact that the time base is the interval between Y pulses rather than a fixed time interval.

Fig. 16-10. Typical commercial counter provides various modes of operation, including time interval counting.

Decade Counters for Analog Time Measurement

When it is desired to know the time interval in microseconds between two digital events or pulses, a variation of the circuit shown in Fig. 16-9 is made. A 1-megacycle clock is connected to the X input, and the unknown pulses are applied to the Y input. The counter decades now indicate the time between Y pulses in microseconds. If only two signals are present, the circuit shown in

*EPUT is a registered trade mark of the Berkeley Div., Beckman Instruments Inc.

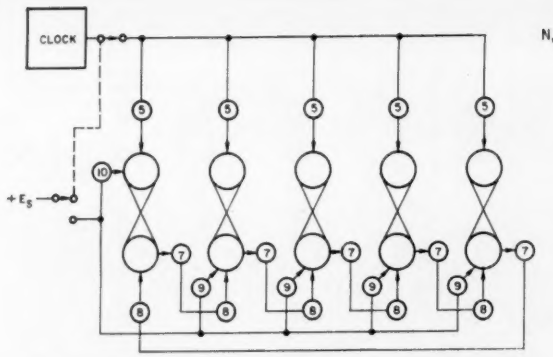

Fig. 16-11. Ring counter uses the slight delay in flip-flop action to enable each flip-flop in succession. Each successive clock pulse thus changes the state of one flip-flop, in succession.

Fig. 16-7 can be used. This circuit would be used, for example, if it is desired to find the time of flight of a bullet or shell over a measured course.

Counting Rings

Another useful electronic counter circuit is the *ring counter*. Fig. 16-11 shows a simple ring-of-five counter.

This circuit uses the slight delay between input and output of a flip-flop to act as a memory for a carry pulse. When the circuit is first turned on, the double-pole double-throw pushbutton switch is depressed. This action first disconnects the clock and then, by means of a large positive voltage applied to preset pin 9 of the right four flip-flops, these counters are reset so that the negative clock pulse input (to pin 5) does *not* initiate a change of state in any of these counters. However, the first flip-flop on the left is preset with its output pin 7 high (in the 1 state). This means that when the pushbutton is released, the clock finds the first flip-flop with the right half conducting (refer to Fig. 16-1) so that the first negative clock pulse resets this first counter stage. Due to the slight delay in the flip-flop, by the time output 7 falls to pass on a negative carry pulse to the second counter, the clock pulse on its input 5 is over. The second flip-flop is then changed over with its output 7 high (1 state). The 1 state has therefore been shifted from the counter on the left to the second counter. The second clock pulse now shifts the 1 state by similar action in the second flip-flop to the third one. With the fifth clock pulse, the 1 state is transferred back from the rightmost counter to its original position in the leftmost counter. This ring action continues as long as the counter bank is supplied with power. (In a following chapter on computers, we will see how a modification of this ring counter is used as a computer shift register.)

It can be seen that a ring of ten constructed in this fashion could be used as a decade counter. The neon glow lamps used to indicate the count in the decade could be connected between the 200-volt B supply and the output (pin 6) of each flip-flop without the matrix of Fig. 16-3. However, since six extra flip-flops are used, more tubes are required, which gives a cost and size disadvantage.

A ring can be used to drive electronic multiplexers (as was described in Chapter 6) without a matrix. There are many other computer and electronic uses for counting rings for sequential control.

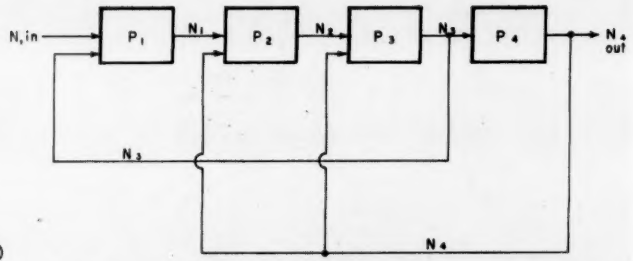

Fig. 16-12. Generalized representation of a cascaded counting circuit with feedback paths.

Generalized Technique for Feedback Counting

The preceding discussion relates to specific configurations for counting. A general approach to the problem of counting by the feedback or forced-count method is as follows:

Each of the blocks of Fig. 16-12 is assumed to be a count-of-two unit (although it can be any order of count). The output of the block is represented by N_n; thus the output of P_1 is N_1, which is the pulse carried forward to the next pair P_2. Note that certain outputs are fed back to previous stages. It is assumed that delays in the feedback paths are such that a distinct pulse arrives during feedback to force the count.

We can write a system of equations for the input of the various triggered pairs (recalling that a triggered pair scales the count in ½). Thus the output of each pair must be ½ its input, as follows:

$$N_1 = \tfrac{1}{2}\,(N_{in} + N_3)$$
$$N_2 = \tfrac{1}{2}\,(N_1 + N_4)$$
$$N_3 = \tfrac{1}{2}\,(N_2 + N_4)$$
$$N_4 = \tfrac{1}{2}\,(N_3)$$

The division or count-down factor is given by the ratio of N_{in}/N_4 because N_4 is the output of the scaling circuit. First, let us write the equations above in slightly modified form:

$$2N_1 - N_3 = N_{in}$$
$$N_1 - 2N_2 + N_4 = 0$$
$$N - 2N_3 + N_4 = 0$$
$$N_3 - 2N_4 = 0$$

Using Cramer's rule and solving these simultaneous equations by determinants yields:

$$N_4 = \frac{\begin{vmatrix} 2 & 0 & -1 & N_{in} \\ 1 & -2 & 0 & 0 \\ 0 & 1 & -2 & 0 \\ 0 & 0 & 1 & 0 \end{vmatrix}}{\begin{vmatrix} 2 & 0 & -1 & 0 \\ 1 & -2 & 0 & 1 \\ 0 & 1 & -2 & 1 \\ 0 & 0 & 1 & -2 \end{vmatrix}} = N_{in}/8$$

Thus the connections made result in a division of the input pulses by eight.

The versatility of this generalized approach is evident. Although the previous example was worked out with triggered pairs (each of which divided by two), it can be extended to other types. As a simple extension, it can be seen that if two of these circuits are cascaded, the output would be 1/64 of the input count. If the output of the preceding circuit is connected in cascade to a simple divided-by-three circuit, a count-down factor of 24 would result.

Myths of Automation

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DURING the past two years I have had the opportunity to study in some detail the experiences of 13 highly automatic production systems in a variety of industries. The trends and results seen there have been checked against the experiences of perhaps another 30 firms in lesser detail. When we examine these industries carefully, instead of hypothesize, the lessons of automation stand out clearly. It is the purpose of this paper to examine some of the fallacies and phobias of automation with view to encouraging all of us to think through the implications of automation more clearly and to eliminate some pointless fears.

MYTH NO. 1

Myth No. 1—That there are fully automatic factories. It has been stated again and again in popular and serious literature that there are not only "automatic" factories, but there are "fully automatic" factories. For three years I have tried to track down such automatic factories and have been unable to find them. The automatic factory turns out to be in every case a remarkable advance in mechanization, but it has not resulted in manless production.

In 1945-46 many rumors were heard about the Government-owned 155-mm shell plant in Rockford, Illinois built by the W. F. and John Barnes Company. It was reputed to be "fully automatic." In the January 22, 1955 number of *The Saturday Review* an article appeared entitled "The American Factory and Automation." It was authored by the chairman of the board and included this quote . . . "Our own company, U. S. Industries, Incorporated, operates perhaps the only fully automatic factory now producing. It is a Government-owned, 155-mm shell plant in Rockford, Illinois. The plant was designed for very high production, using 20% less manpower, both direct and indirect than in conventional plants . . ."

If it uses only 20% less manpower than a conventional plant, is it "fully automatic"?

As a final example let us take Ford's Cleveland Engine Plant. In *Business Week* an article appeared describing Ford's Cleveland Engine Plant. The article was entitled, "Automation: A Factory Runs Itself." During my visit to this plant in mid-1954 I found that over 4500 people were at work in this plant and more than 2700 of these were on the production line. This 2700 did not include quality control personnel, material handlers, or the maintenance force. It is somewhat difficult to understand how a factory with 2700 production line workers can be said to "run itself."

Abstracted from a paper presented before the Society of Automotive Engineers, Detroit, Mich., Jan. 14-18, 1957.

MYTH NO. 2

Myth No. 2—That automatic manufacturing requires feedback control. A favorite phobia of the Sunday supplements is that automatic factories and automatic machinery have suddenly become possible and tremendously more significant because of feedback control. I have examined several hundred automatic machines in about 30 highly automatic production systems and found only oil refineries to show a significant amount of feedback control.

Table I—Motives and Benefits of Automation in 13 Firms

Characteristic	Number of Plants Experiencing This Characteristic As		
	Primary Motive	Secondary Objective	Unexpected Benefit
Increased capacity	11	2	
Reduced direct labor content per unit of output	12		
Reduced indirect labor	8		3
Shorter lead time	2	1	3
Higher quality of product	8	1	2
Reduced scrap	1	2	7
Increased Equipment Utilization	2		2
Ability to expand production without major work force increases	1		
Improved safety	1	3	1
More attractive working conditions	1	2	5
Easier production control job		1	2
Easier plant administration		3	
Lower maintenance cost	1	1	1
Lower capital investment	1		
Increased Flexibility in products manufactured	1		
Less skill and training required of some workers		1	5
Shorter setup time			2
Reduced floor space requirements		2	2
Reduced work in process inventory	1		2
Easier housekeeping	1		6
Reduced insurance cost		2	
Sales promotion value of new plant			3

Feedback does not appear often because it is not necessary to much automatic production. Feedback control assumes that the machine needs to be corrected. But many machines do not need correction. They operate with quite adequate precision; their product falls well within the desired specifications. Since the need for self-correction is not great, feedback has no economic value.

MYTH NO. 3

Myth No. 3—That the only motive for automation is cost reduction through the elimination of labor. The experience in 13 firms studied showed an astonishing range of motives as well as unanticipated benefits and secondary objectives that were not quantified. These are listed in Table 1. There are several important points to be made about this table.

The advantages of automation are far greater in number and often in value than the average firm realizes. I would estimate that not one firm in a hundred *thoroughly* explores the favorable (and negative) aspects of automation proposals. They rarely quantify anything but labor savings, and hence overlook some splendid and valuable contributions.

Consider lead time, for instance. A parts firm cut lead time from 19 days to 2-3 days; an oil refinery from 4 days to 5 hours; a feed mill from 2 man hours to 5 man minutes. What would this mean to the average firm in customer service, in inventory reduction and in production planning?

Another firm justified their automation program solely on reduction of scrap. Still another adopted automation solely to provide working condition improvement. Automation made it possible for them to attract and hold women workers in a very tight labor market.

Engine plants have found that automation increases equipment utilization from about 60% to 80%. This is a *clear gain of one-third in production capacity without corresponding investment or plant expansion!*

Some of these other motives appear quite strange—product flexibility, for instance. Yet the fact is that a fertilizer plant adopted automation because it enabled immediate pushbutton mixing of any of 500 formulations. Such product flexibility is totally beyond the conventional plant.

Reduction in capital investment also is completely contrary to traditional automotive industry thinking about automation. The fact is that this was *the major reason for automation in the most automatic plant I studied (an oil refinery).*

Lower maintenance cost is also a surprising advantage. We shall see why it, too, may arise out of automation.

The lesson is clear: It is a mistake to think of automation as yielding a limited, fixed set of advantages and disadvantages. These vary widely and wildly depending upon a host of factors in the individual case. Management should carefully explore the full range of implications and quantify them wherever possible. Labor savings alone is a very naive and inadequate approach.

MYTH NO. 4

Myth No. 4—That automation must cost more than a conventional system. This is not always true. The oil refinery I studied adopted automation primarily because the conventional plant would have cost $1,000 per bbl of daily thruput, while the automated plant cost only $700/bbl. How can this be? Simply expressed, the automated plant was an integrated system eliminating much in-process tank storage and associated piping and pumping mechanism, as well as requiring only one control center instead of four. Thus automation cost less not because the equipment was cheaper, but because there was less of it.

MYTH NO. 5

Myth No. 5—That automation inevitably raises maintenance costs. Many automotive and electrical equipment manufacturers will insist that this is so, and it often is. Yet *the two most automatic plants* I studied actually reduced their maintenance costs and difficulties by automation!

Oil refineries generally expect that the maintenance force will be 50 to 60% of the total refinery work force. In the automated refinery mentioned above the maintenance force is about 20.5% of the total refinery force. Why? It is because there is significantly less machinery—pipes, valves, controls, pumps, etc.—to maintain per unit of output. The maintenance is not directly proportional to the amount of automatic equipment or the degree of automaticity, but to the total amount of machinery. Reduce this machinery enough and maintenance will fall off, too.

Another misleading thing about maintenance is that the figures and experiences reported are totally misleading: The thing called maintenance usually is a blend of installation, debugging, routine servicing (lubrication, cleaning, adjustment), downtime for total replacement, housekeeping, maintenance of tooling fixtures (as distinct from the production machine), breakdowns, etc.

I have found no plant that has figures isolating each of these factors. They are all lumped together and charged to maintenance. Thus "maintenance troubles" in automated plants often turn out to be "installation" or "debugging" costs.

MYTH NO. 6

Myth No. 6—That automation inevitably means upgrading of labor skill requirements and severe retraining problems. It is one of the phobias of some elements of organized labor and some social scientists and industrialists that the average worker is unemployable in the highly automated plant. This study throws a great deal of doubt on the certainty of this end effect. The evidence in these 13 plants is mostly to the contrary. To the extent that employment opportunities are available (a) operators' jobs often are easier and more quickly mastered in the automated plant and (b) the impact on the quantity and quality of maintenance skills required *may* be much less than expected.

The ultimate argument, of course, is to point out that this machine evolution leads to the very situation feared: Automaticity grows until *no* operators are required. Then what employment opportunities exist? Only maintenance and design. The level of education required on some of these design jobs is of PhD caliber. The maintenance skills may require electronics training. Now the unskilled or semi-skilled worker is helpless. He does not even understand the language, let alone the job.

This grim ending neglects to account for several counteracting facts:

1. It is the trend of invention to mechanize difficult jobs.
2. The economics of machinery bar the introduction of *fully* automatic machines in hundreds of thousands of installations. Man is a far cheaper and more flexible control device than the ultimate "feedback" mechanism for many machines.
3. Industry is by no means the mass production world so often pictured.

Thus, automation does not tend to make people unemployable because they lack skill and specialized education. On the contrary, many (and perhaps most) *operator* jobs can be mastered more quickly, with less job experience, special skill and education, as mechanization increases and provides increasing degrees of automaticity.

Furthermore, there is a good possibility of *lowering* skill requirements and shortening the training period on many operating jobs.

MYTH NO. 7

Myth No. 7—That automation has nothing to offer labor but unemployment. It seems true that many (and probably most) automation programs aim at reducing direct labor content *per unit of output*. However, most automation programs also are sparked by the need for increased capacity (see Table 1). Depending on the amount of labor reduction and the amount of capacity increase required, the net effect on labor can be anything from unemployment to far greater employment opportunities.

Although the net effect on employment opportunities is uncertain, there is no doubt at all that automation offers the worker distinct job advantages:

1. Easier work, physically and mentally.
2. More interesting work through variety of job activity.
3. A more satisfying job through a sense of responsibility for a larger portion of the end result.
4. Pleasanter job surroundings.
5. Higher pay through increased productivity.
6. The satisfaction and prestige of working in an outstanding plant.
7. Greater job security against both the efforts of the firm's competition and the effects of old age on the individual's strength, dexterity and endurance.
8. Greater continuity of employment.
9. A safer job.
10. Opportunity to learn more of the total production process and machinery.
11. Experience with advanced equipment that may be even more valuable as time goes on.

Of course, all these things do not apply in every situation. The point simply is that the worker has much to gain from automation. Why not tell him so?

MYTH NO. 8

Myth No. 8—That automatic machinery alone is responsible for sensational advances in automatic manufacturing and productivity increases. Study of manufacturing evolution in any industry will show that at least five major factors are involved in technological improvements.

1. Spatial rearrangement of machinery. For example, in one effort productivity gains were fantastic although there was no introduction of automatic machinery. The gain was simply the refinement of a concept of arrangement, and the eventual mechanization of movement (although great gains were made without even this simple bit of mechanization).
2. Changes in materials to facilitate automatic production.
3. Changes in processes to facilitate mechanization. Some of the most dramatic production gains come from the adoption of new processes; for instance, stampings and castings vs. machined parts.
4. Changes in product design.
5. Automatic machinery.

Thus, to look to automatic machinery as the sole hero or villain of automatic production, productivity increases and/or labor displacement is industrial naiveté of the first order.

Uncommon Uses for Common Digital Computers

MARTIN L. KLEIN
Rocketdyne Div.,
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COMPUTERS are now established as expensive but economical contrivances which perform a series of elementary-school operations rapidly enough to supplant human efforts in some measure. The words "in some measure" are used with malice aforethought because it is only in performing the simplest and most repetitious operations that a computer gains any real advantage. Notwithstanding, a whole tribe has sprung up, devoting their off hours to amassing huge electric bills in proving that computing machines can do things for which they were not intended. We propose to bring some of these activities to light.

Computers and Predictions

One of the most intriguing activities for common digital computers is in crystal-ball gazing. The most significant step (backwards) developed during the 1952 Presidential election, when a group attempted a running prediction of election results. The circumstances surrounding this enduring "goof" are shrouded by conflicting accounts which variously place the responsibility on UNIVAC, the Lockheed Corporation, the Metropolitan Lighting District (which allegedly supplied the 110 volts ac rather sporadically) and/or the National Broadcasting Company (for conjuring up the whole idea). Nevertheless, nobody was hurt; the election ran off without incident, and so did the programmers.

The computer industry regained some face in January, 1956, when DATATRON, with considerable good fortune and line regulation, correctly predicted the outcome of four out of five of the principal Bowl games, outpredicting the entire nation's handicappers. For six months the science fiction writers and motion-picture industry restored the computer to its incorrect position of superbrain.

At this juncture, *This Week*, which visits some thirty-million families weekly, came up with a perfectly horrendous idea. They asked, "Why don't you predict the outcome of the teams in both major leagues?" We should have quit while we were even, because we tried it and the results are too embarrassing to discuss dispassionately. The only correlation between the predictions and the National and American divisions appears to be in the Woodland Hills Little League; this is our story and we're sticking with it.

Some months ago, a scheme based on substantially the same techniques was investigated at MELPAR. It was announced that a technique had been devised and tested

An address delivered at the ACM Convention, Aug. 27, 1956.

for beating the bookmakers at their own game. Tested against last year's results, the user would have received $80 for each dollar invested. Since then, not having learned our own sad lesson, they have turned to a similar method for beating the stock market. We had intended to have Dr. Rosenfeld, who developed this scheme, discuss it himself. However, since he has been testing the technique, we felt he might not have the wherewithal to make the trip.

I would be remiss not to mention in passing, since we are dealing with games, an enormous collection of parlor games now being inflicted on computing machines. Best known, of course, is Tic-Tac-Toe, which was frowned on as a class activity during the same school years we were learning how to play it electronically. We reach the highest state of this art in a recent proposal to pit one machine against another in a titanic struggle of magnetic cores—to the enlightenment of nobody in particular but to the enormous delight of the IBM Rental Department. This is being brought to final fruition in a series of studies to make a computer play chess; this strikes me as a perfectly elegant idea because the game is highly time consuming and difficult, and it will save a lot of people considerable time, effort, and friendship. All of these programs are disconcerting, because when the machine gets hot it is extremely difficult to outmaneuver. When the wall-plug gets hot, something is wrong with the machine.

One of us owes a considerable amount to the computing profession. In fact, he owes well over a million dollars and his name is George Gobel. On the Seventy-fifth Anniversary of Light, a program viewed by forty million people, he brought forth what is now a standard American statement, "you can't hardly, etc." Up to that night he was unknown outside of Chicago, although he was equally funny back in the time B.C. (Before Computers). Nevertheless, in a ten-minute sermon on computers (which the men in the grey flannel suits decided was too good for people and so interrupted with a station break) he simultaneously placed himself and the computer in the class of institutions.

Computers and Music

As long as we are talking about television, we might recount some of the other efforts along these lines. Not long ago, the DATATRON, fresh from its activities in the baseball field, launched into the field of popular music. This was done on the supposition that if humans could write miserable music that could become popular, a computer could do it more miserably quicker, thus speeding the evolutionary process. This historic event was recorded for eternity in the words produced by Jack Owens, writer of the Hut-Sut song, for the tune "Push Button Bertha!" And so today we hear from our radios:

She's Push Button Bertha, sweet machine,
what a queen.
Pay the light bill and you're right, Bill.
Ten weight oil makes her loyal.

This fiendish couplet has suffered every indignity except recording by Elvis Presley. The only person who has gone on record as liking it is one commentator who has also gone on record as disliking everything else.

Music is being further manipulated by Messrs. Smith and Isaacson in the form of string quartettes, using a machine known as ILLIAC, which I first thought to be a popular presidential intestinal disorder.

Also in the field of music, it might be pointed out that it is possible to connect an audio system to a computer and program the machine to play something that sounds much like music. This costs about $300 an hour and is exactly double the cost of hiring Harry James and his Music Makers. What is incredible about this whole sordid affair is that people actually take it seriously. I was unfortunately connected with the *"PUSH BUTTON BERTHA"* effort on a TV program and received a letter from a teenager that began "Dear BUM." The reviewer for *Variety*, a trade paper, devoted a whole column to appeasing ASCAP songwriters that the songs had "no heart"; the musicians' union hewed right to the line of pinpointing this as another inroad on musicians' security, and I have become as popular in musical circles as a hernia at a weightlifter's convention.

Despite everything so far, there are some unusual academic uses for these machines. In the past year or so, considerable success has been obtained in the field of language translation; in particular, Spanish to English and Russian to English. This is no mean feat because, as anyone knows, everything said in Russian has a double meaning. It is my understanding that this project is now progressing in full force under the sponsorship of the United States Army. (If this is truly an Army-sponsored translation program, I am convinced, as an ex-Navy man, it will be of no practical use until they enter the domain of the four letter words.)

Computers and Humanities

It should not be surprising that we find another effort of the computing machine in the field of biblical investigation. In this program the investigator is using the computer to compare different versions of the Bible, word by word, to determine similarity in different parts. In other words, what he's trying to do is to find out which of the Apostles is stealing material from the other.

There is another very cryptic form of human culture which is known as Abstract Art, in which fully-grown men spend their time making meaningless doodles on an expensive piece of canvas for which wealthy people pay large amounts of money. I'm pleased to report that a computer has now been successfully used to generate these abstract art forms. (I personally cannot tell which of the canvases were painted by a human being, which by the machine, or which was just a dirty piece of canvas to begin with.) Right in line with this technique, a serious suggestion was put forth by a well-known textile organization in which they hoped to dispose of their art department and replace it with a computer, which they felt would do at least no worse a job and which would get rid of their union difficulties. I was personally interested in undertaking this project, which was related to women's clothing, but when I insisted on a live model the whole project fell through. I'm told that they are looking for less demanding project engineers and are getting ready to go ahead anyway. They'll be sorry (they let me go).

After the introduction of computer music on television last July, the notoriety led to a considerable number of inquiries which I think are interesting. One of them came from a Las Vegas gaming room, sometimes known as a gambling den, in which they hoped to replace two-hundred one-arm bandits with one digital computer. The price of a large-scale computer did not appear to faze them, and I understand this project is materializing rapidly. The computer will not only generate the random numbers and keep records of the financial transaction, but it can easily be fixed.

It might be appropriate to mention a TV program which strikes an all-time low for this medium. (The reason television is called a medium, incidentally, is because nothing is ever rare or well-done.) This program, known as "MAN AGAINST MACHINE," stars not Arlene Francis, not Steve Allen, but a computing machine. During the course of a thirty-minute period, this machine

Modern TV show in Los Angeles features battle of wits (?) between ALWAC computer (background), computer expert (Dr. Klein, right) and conventional assistant (second from right) against team of sports experts—KABC-TV's Bob Arbogast (left), Bud Furillo of the Los Angeles Herald-Express and John Hall of the Los Angeles Mirror-News (center). Computer team won, but the human team claimed that computer-team member "Miss Adventure" reduced its normally rapid reaction rate.

competes against a panel of experts in answering a series of questions proposed by the moderator. It works something like this: In advance of the program, the questions and answers are loaded into the memory. At the appropriate time during the program, the coded question is run through the machine by a highly improbable-looking blonde. When the moderator presses a button, the panelists and machine engage in a race to answer the questions. These questions run the gamut from "Who was Artie Shaw's third wife?" to "On what day of the week will July 4, 1987 fall?" Each time the panel succeeds in beating the machine, they add to a pile of worthless prizes, reaching a series of plateaus until—the payoff question—the winner gets custody of the machine (or perhaps custody of the blonde—this matter has not yet been settled).

The Future

All these examples show the limitless ways that computers can be misapplied. But the end is not in sight.

The computing machine designer has one objective—to construct a digital computer which occupies no space, uses no power, and performs a thousand or so distinct operations on a memory that holds an infinite number of words. As a result, we have seen progressively smaller and smaller elements used in the machine—first mechanical gears, then vacuum tubes, then transistors and, recently, cores.

Within the past few months, an announcement has been made which indicates that we have now run the full circle and are back at the beginning again. There is a phenomenon known as super-conduction which is a property related to certain metals. If these metals are held at a sufficiently-low temperature, somewhere in the region of 4°K, a current introduced into the metal wire will flow for an infinite amount of time. This experiment has been undertaken at MIT and a current has been running in a wire, without any battery connection, for months. This suggests to computer designers, whose prime objective is never to use whatever anyone has used before, the perfect memory. It takes no power to hold a word in storage, and virtually no space, or so it would seem. However, a brief computation of the refrigeration equipment necessary to maintain the temperature at 4°K indicates that the size of the computer would be roughly five times that of the one it replaces and the power consumption for this peculiar type of air conditioning is about quadruple what the machine would have used originally. Despite this, we've continued the design of such a machine because one never can tell when we will wish to place an IBM 704 in the middle of a glacier, and if this ever happens, we'll have the answer at hand.

As long as we're talking about memory, we might mention a few uncommon efforts in this direction. Somebody, somewhere, at sometime has stated that the average human memory is equivalent to twenty billion bits. This is one of these mystic numbers that materialize and then become gospel around which we all design. There are serious considerations afoot to construct a memory approaching this capacity: twenty billion bits. When this happens, and it will happen, we will then be able to reach into a new world. At the present time it is customary to use a computer to synthesize an airplane, a rocket, or a chemical process. With this new computer, which ought to be MAN I, we will be able to synthesize a human being. Exactly why anyone would want to synthesize a human being when there are considerably more pleasant ways of arriving at the same construction is something of a mystery to me, but I predict that we shall see this happen within the next ten years.

In summary, it is evident that there are many uncommon uses for the ordinary digital computer. Not all have been tried. For example, with their tremendous power consumption, they would do a wonderful job of heating a house.

General-purpose Integrator for Data Reduction

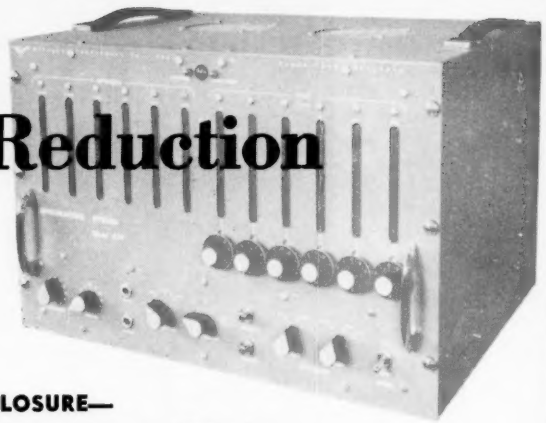


Fig. 1

HARRY STERN
Allegany Instrument Company

—AN EXCLUSIVE FIRST DISCLOSURE—

New instrument accepts analog voltage signals, converts to digits by heterodyne technique, and then counts or integrates area under signal curve. Input signal changes frequency of 100-kc reactance oscillator by 10 kc, giving count rate of 10,000 counts per second. Integral can be (1) total area under curve, (2) area above a preselected signal level, (3) area under curve for preselected time intervals, etc. It provides highly accurate measurements of velocity by integrating acceleration vs time, energy by integrating power vs time, impulse by integrating force vs time, or the time integral of any analog signal.

PERFORMANCE CHARACTERISTICS of propellents, fuels, missiles, engines, and many other devices involve measurements of the *area under a curve* of pressure vs time, thrust vs time, etc. Measurement of average torque, average stress, energies, distances, quantity, impulse, velocity, and other variables also require integration of areas under curves. In the past, such integration has been done primarily by manual arithmetic computation or planimetering, both time-consuming operations.

Several electronic automatic techniques for such curve integration have been developed in the past few years, for example, by Wiancko and General Electric. These systems generally have used pickups such as variable-reluctance and frequency-modulated gages that acted as analog-to-digital converters for the variable in question. Once converted into digital form, integration is simply a matter of appropriate counting circuitry.

Such integration is so important for a host of measurements that there is need for a general-purpose integrator that will accept any analog-type signal (voltage) and automatically integrate either the total area under the curve, or parts of the area selected either on a voltage amplitude or time basis. This is the reason for the development of the Model 270 Integrating System, a general-purpose all-electronic instrument for obtaining the time integral of a varying input signal. This is the first disclosure of the system.

Fig. 1 shows the instrument; Fig. 2 is the block diagram. When there is no input signal the reactance tube oscillator is tuned to 100 kc. There is no beat now resulting in the mixer because there is no frequency difference between the reactance-tube oscillator and the 100-kc oscillator. When a signal appears at Point A, it is amplified and causes the frequency of the reactance tube oscillator to shift, producing a beat note at the input to the integrator gate. If the gate is open, these counts are stored in the integrator DCU's. As the counting rate is directly proportional to the input voltage, the total count is the summation of the incremental values of this voltage, which is the integral.

The timer not only allows calibration of the system by opening the gates for a known time, but also provides a measure of the phenomenon time base when the gates are opened and closed during the test.

By means of programming circuits and preset counters, various means for starting and stopping the integration are available. The integration may be started at (1) a preset signal level, or (2) by closing a set of contracts. It may be stopped by (1) signal decay, or (2) preset time. Any start-stop combination can be used.

The change in frequency of the reactance-tube oscillator is linear with the amplitude of the input signal. A 1-volt input causes a frequency shift of 10,000 cps, producing a maximum count rate of 10,000 counts per second. One of most interesting features of the instrument is that when it is operated for a short specific period of time, it becomes an analog-to-digital converter, providing the average analog value of the variable measured during that specific time interval.

The Model 270's counting rate of 10,000 counts per second provides a good compromise between resolution and total counts storage. For short-term phenomena, 100 milliseconds would provide 1000 counts for a readability of 0.1%. For long-term phenomena (longer than 100 seconds) provision has been made so that a mechanical counter can be employed to indicate counting beyond the capacity of the time and integral counters on the instrument. Output connectors have also been provided so that both time and integral values can automatically be fed onto tape or printed out by typewriter.

Success of the heterodyne technique depends on the stability and drift of the oscillator circuits. Careful use of precision components has reduced the drift to 100 counts per hour and increased the stability to 1%. As the accuracy of the integrated signal is proportional to the time of duration of the signal, the drift and stability factor decreases in importance as the signal duration in-

creases, and becomes insignificant for most measurements involving seconds or minutes.

The various modes of operation are shown in Fig. 3. In the graphs, the shaded areas represent the integral, or highly accurate summations of incremental functions of time, with the X-axis as time and Y-axis as analog signal.

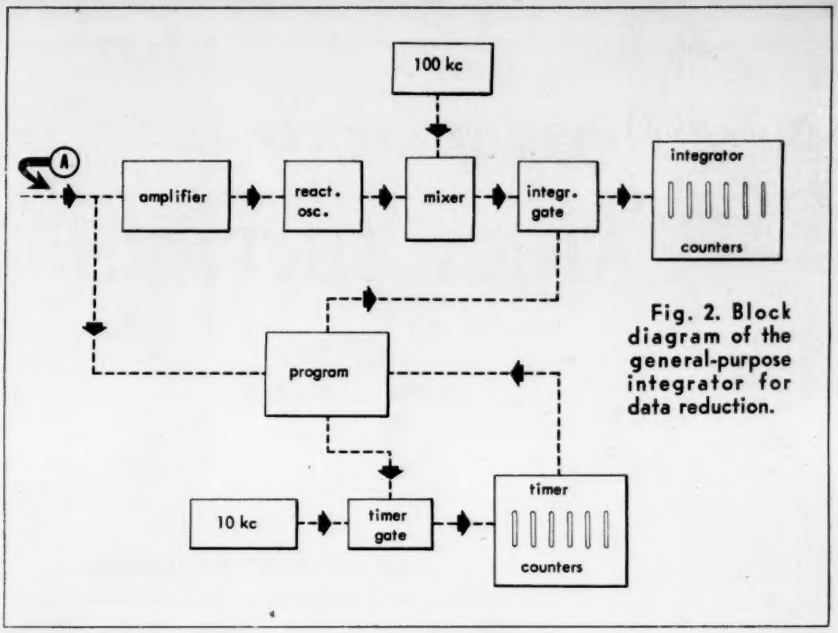


Fig. 2. Block diagram of the general-purpose integrator for data reduction.

Typical Applications

Graph A in Fig. 3 shows a thrust-time integral to obtain impulses of a rocket during a static firing. The signal from the amplifier, which is connected to the load pickup, is connected to the input of the Model 270 (an amplifier is usually necessary due to the low output of the pickup). Full scale load (say 1000 pounds) is then applied to the load pickup or (a popular alternative) a calibration resistor is merely shunted or placed in series with one arm of the load pickup to electrically simulate a full-load condition in the output of the pickup. The gain control is then adjusted for an integral count of 10,000. This completes the calibration and the instrument is now ready to operate.

The START SELECTOR and the STOP SELECTOR are set to the "signal" positions. The Integrating System will commence counting both time and integral when the rocket is fired and a resulting signal fed to its input. It will stop counting when it no longer receives a signal. If it is desired to integrate only the first portion of the thrust-time curve (as in rocket igniter studies) the STOP SELECTOR is merely set to "preset" instead of "signal" and the preset dials beneath the time counters are set to the desired measuring time. This can be any amount of time from 0.0001 to 100 seconds in increments of 0.0001 second.

After the rocket has stopped burning, the time counters display the total time of thrust, while the integral counters display the integral of the thrust-time curve (impulse) as a simple proportion. Thus, if the time counters read 100,000, the action time was ten seconds; if the integral counters read 080000, the actual integral or impulse is expressed as: Impulse/Full Scale Load=Integral Reading/Calibration setting = 080000/10000 = 8000 lb-sec.

Dividing the integrated value (8000) by the action time of the phenomenon (10), we find that the average thrust during that particular test was 800 pounds.

Other typical applications are:

1. Integration of pressure-time curves
2. Integration of force-time curves
3. Continuous process weighing
4. Totalizing illumination
5. Moisture determinations on continuous processes
6. Integration of acceleration-time curves
7. Integration of velocity-time curves
8. Integration of torque-time curves
9. Totalizing varying RPM
10. Integration of temperature-time curves

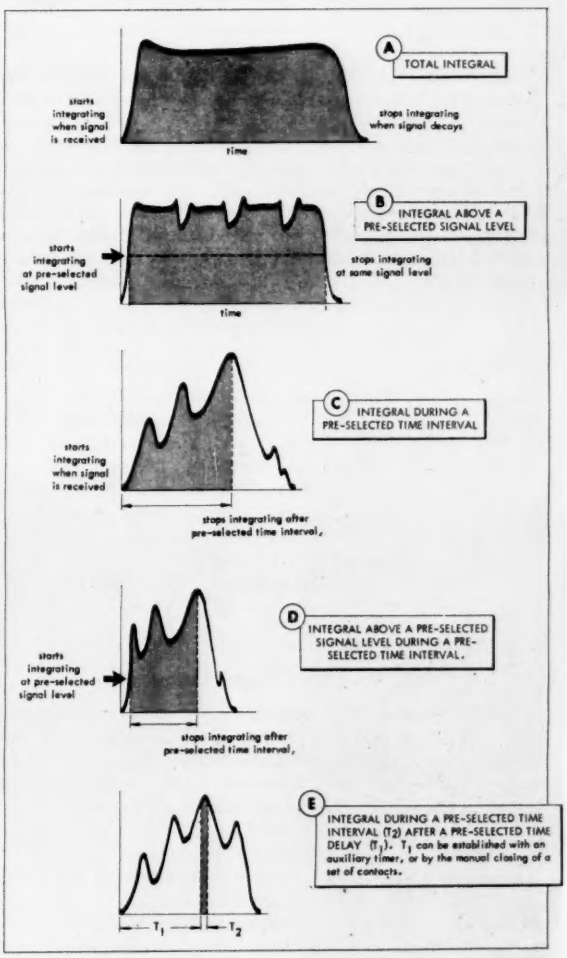

A
TOTAL INTEGRAL
starts integrating when signal is received
stops integrating when signal decays
time
B
INTEGRAL ABOVE A PRE-SELECTED SIGNAL LEVEL
starts integrating at pre-selected signal level
stops integrating at same signal level
time
C
INTEGRAL DURING A PRE-SELECTED TIME INTERVAL
starts integrating when signal is received
stops integrating after pre-selected time interval,
D
INTEGRAL ABOVE A PRE-SELECTED SIGNAL LEVEL DURING A PRE-SELECTED TIME INTERVAL.
starts integrating at pre-selected signal level
stops integrating after pre-selected time interval,
E
INTEGRAL DURING A PRE-SELECTED TIME INTERVAL (T_2) AFTER A PRE-SELECTED TIME DELAY (T_1). T_1 can be established with an auxiliary timer, or by the manual closing of a set of contacts.
T_1
T_2

Fig. 3. Modes of operation.

New Developments in

AREA METERS

GEORGE H. SEEMAR

The C-Mar Corporation

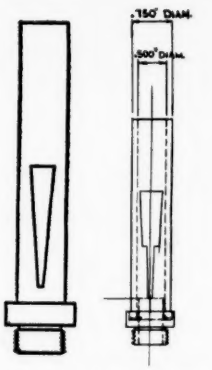


Fig. 1. Typical port areas that can be fabricated by ultrasonic impact grinding.

—AN EXCLUSIVE DISCLOSURE—

Refinements in production technique—ultrasonic impact grinding, precision bore tubing, careful surface finish control—make possible reproducible orifices in area meters and reliable repeatability of measurement.

IMPORTANT DEVELOPMENTS need not include new concepts; refinements in manufacturing technique can reduce or eliminate roadblocks which retard the advancement of established instrumental concepts.

There are two basic types of variable-area flowmeters —the rotameter and variable-port (or area-type) flowmeter. The rotameter has achieved greater acceptance than the "area meter" flowmeter because of two factors —(1) friction associated with the necessarily close-fitting piston in the cylinder with the variable port has contributed to deficiencies in readability and (2) ports could not be machined in glass or ceramic tubes with the high accuracy and reproducibility desired for industrial flowmetering applications. Hence the area meter has been used primarily for viscous fluids, hot tar, black liquor, and where the presence of mercury is detrimental, with most other applications being given to the rotameter-type variable-area flowmeter and mercury meters.

Attention has been returned to the variable-port area meter in light of modern developments in precision bore tubing, ultrasonic machining, and fine surface finishing. By applying these modern fabrication techniques, it has been possible to eliminate deficiencies which have, in the past, retarded wider acceptance of the variable-port idea.

The Variable-Port Flowmeter

The principles of the variable-port-type area flowmeter have long been known. In its most familiar form the fluid enters the flowmeter at the bottom of a vertical tube containing a sliding-fit cylinder or float. As the float rises, it uncovers the port or orifice in the wall of the cylinder and discharges into the annular body of the meter (Fig. 1). The equilibrium position of the float for a given flow rate is reached when the pressure difference across the orifice balances the float weight. The pressure in the annular space downstream of the orifice is transmitted to the top of the float. This pressure differential, which is caused by the head loss across the orifice, is constant for all flow rates because it depends only on the weight of the float.

The Reproducible Orifice

The first innovation reported here is the use of ultrasonic impact-grinding technique (Fig. 2) to produce orifices of guaranteed reproducibility in metals, glass or ceramics. The orifices are produced by first forming a tool to the exact specifications for a given tube size. This tool, made of stainless or cold-rolled steel, is the same configuration as the orifice to be reproduced. The tool is undersized to compensate for the Norbide grit which is used in the cutting process.

The tube (steel, ceramic or glass) is secured in a fixture and placed in position on the table of the ultrasonic impact grinder. The sized tool is silver brazed to a monel steel tool cone which is secured to the electromechanical transducer. The table of the grinder is raised to position the tube against the cutting tool. Vibrations of the transducer are transmitted to the cutting tool at the rate of 25,000 cycles per second. The Norbide grit is pumped against the tool face. A small space filled with the abrasive fluid develops between the vibrating tool face and the work piece. Tiny particles of abrasive are accelerated by the motion of the tool tip and are driven with tremendous impact against the work, thereby grinding an exact counterpart of the tool face into the work.

Using this method it is possible to calibrate one master tube of any given size, and the resulting linear curve is applicable to any tubes of the same size, regardless of the quantity. Curve charts are sent to customers with each meter; replacement tubes to the customer's order are guaranteed reproducible to the master curve.

Friction Effects

The second basic innovation is the use of precision bore tubing for the cylinder, and precision float manufacture to a tolerance of 0.002". Nickel plating is used on the float to produce a surface finish of high accuracy and flatness. The result of this manufacturing technique is to reduce the friction between the float and the cylinder wall to an insignificant amount—friction is so reduced that the flowmeter is not affected by a 45-degree change from the normal vertical mounting position.

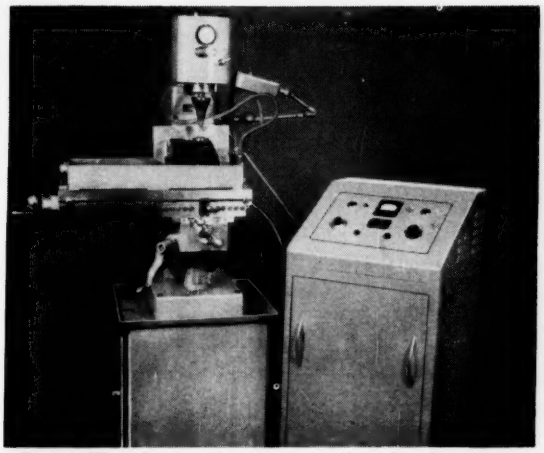


Fig. 2. The ultrasonic impact grinder, developed especially for area-meter work.

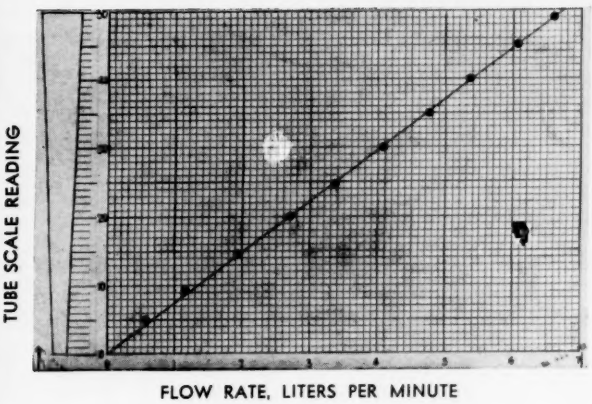


Fig. 3. Typical calibration curve.

Features and Advantages

The construction technique developed permits full use of the features and advantages associated with the area meter—linear response (due to port shape) and ease of range change (simply by change in weight on the piston). Fig. 3 shows a plot of an actual calibration; Fig. 4 shows the maximum and minimum flow rates possible simply by changing the weight or material of the float. Fig. 5 shows a high-pressure (15,000 psig at 100°F) flowmeter for use with liquids and gases. It is used here with an "Atcotran" explosion-proof differential transformer for signal transmission.

Extremely low gas flow rates are of particular interest in many fields; "Tapor-Flo" tubes of 2 and 3 millimeter diameters are being tooled.

One specific feature that found ready application in motor test work has been the double orifice (Fig. 1). This specially designed custom orifice permits linear flow, both at low idling rates and at high consumption rates during maximum power output.

It is expected that this disclosure of refinements in the manufacture of the area-type flowmeter will return attention to this type of flowmetering and accelerate the development of this phase of instrumentation.

Fig. 4. Area meter range can be varied through wide limits simply by changing float weight.

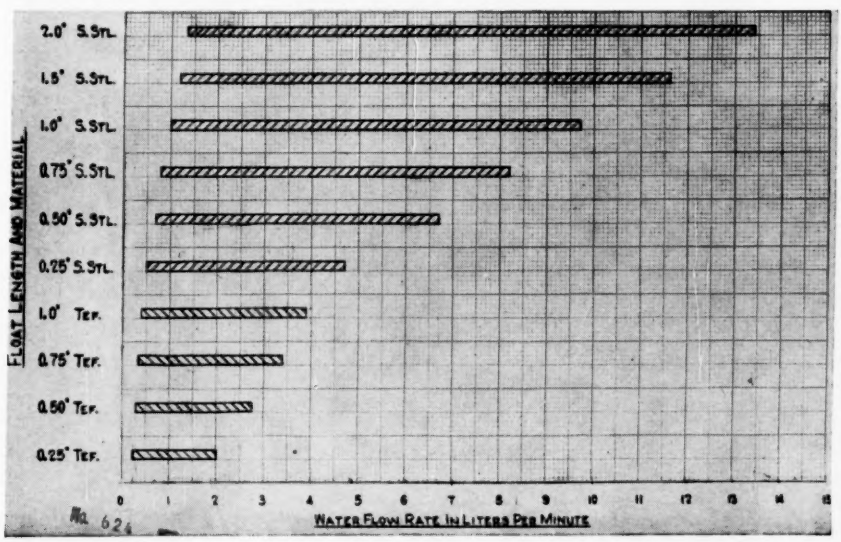
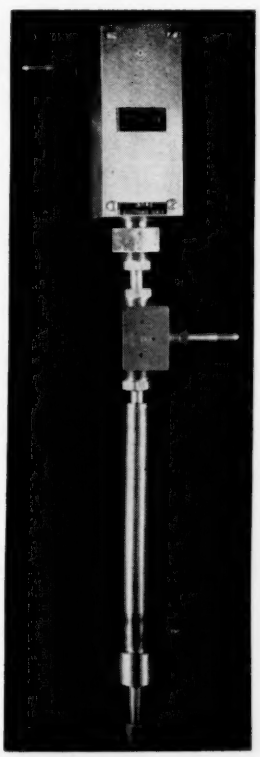
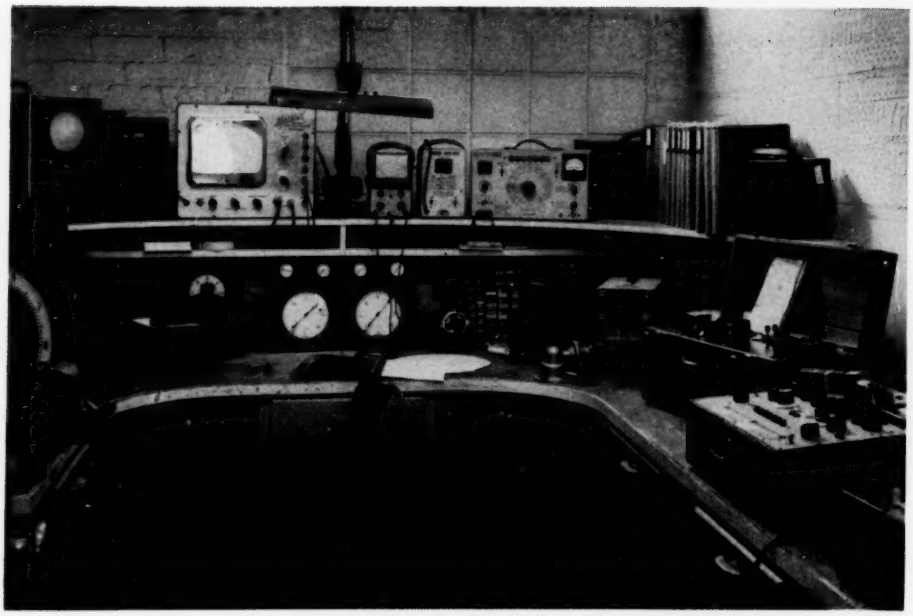


Fig. 5. High-pressure flowmeter with differential transformer for signal transmission.



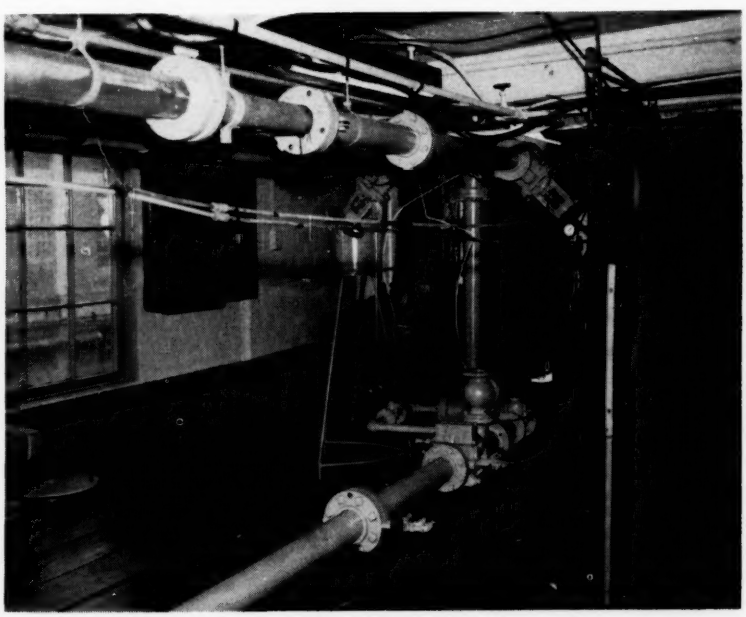


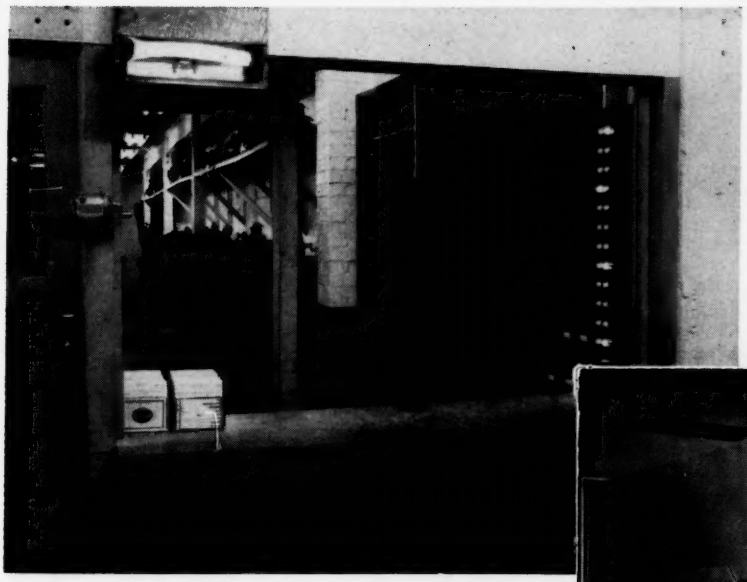
Electronic instrument test bench contains complete array of conventional test instruments, plus a precision potentiometer and a parameters analyzer.

Process ⇄ Instrumentation

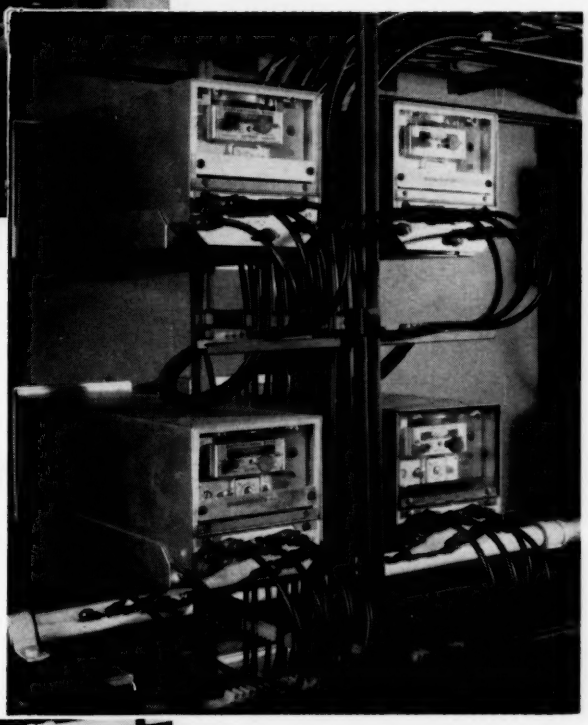
CARBIDE & Carbon Chemicals Company, South Charleston, W. Va., produces bulk organic chemicals. The instrument department serves not only the plant, but also the company's Research and Development center and the Design and Construction Engineering groups, which are also located at South Charleston. On Page 231 you met Tommy Thomas, Chief Instrument Engineer of Carbide & Carbon Chemicals Company; here are some closeups of the Instrument Department itself, the Instrumentation Engineering Lab., and the Hydraulic Test Lab.

View showing portion of hydraulic test system in the Instrumentation Engineering Laboratory.

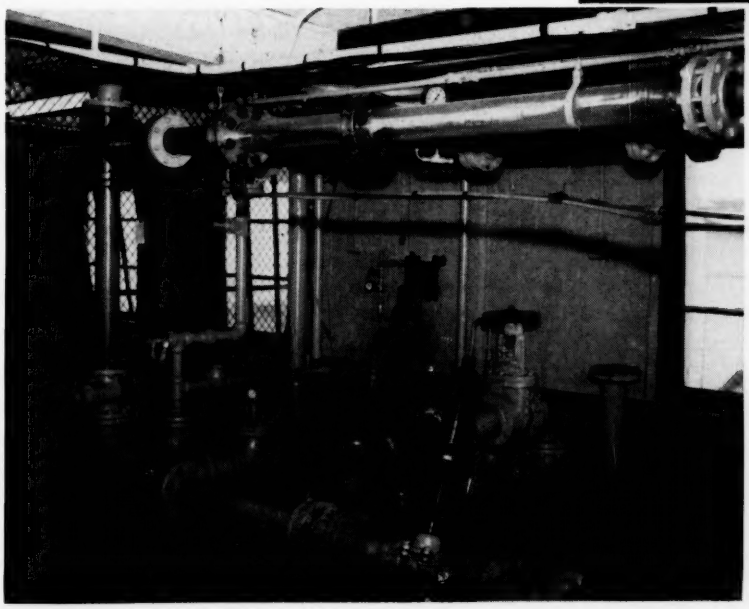




View of Instrument Division storeroom service window.



Close-up view of a typical instrument panel piped with polyethylene tubing, the development of which, at Carbide & Carbon, changed the cost picture for pneumatic instrument installation.



Hydraulic Test Laboratory, showing 4-inch plastic orifice run for visual inspection.

ELECTRONIC

MILTON H. ARONSON
Instruments & Automation

and

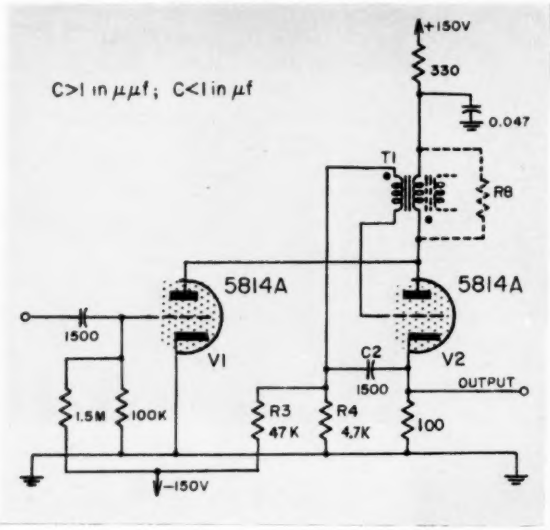
CHARLES F. KEZER
Key Electric Corp.

PARALLEL-TRIGGERED BLOCKING OSCILLATOR HAS FAST RECOVERY

Triggered blocking oscillators are used in radars to produce synchronizing pulses for modulators and indicators. They are used also in computers because their low output impedance allows them to trigger dozens of flip-flops with little effect on pulse shape or amplitude.

This circuit produces a pulse with duration of from 0.1 to 2 usec when triggered by an input pulse. Triggering pulses can be separated by as little as 12 usec. Circuit is NBS-BuAer Preferred Circuit PC47.

The blocking oscillator (V2) is cut off, in the absence of a trigger pulse, by the 15-v bias developed across the divider R3, R4. The trigger triode, V1, is normally cut off by a similar divider. A 30-v positive trigger pulse at the grid of V1 produces conduction in that tube, and the common plate voltage drops. This negative pulse causes a positive pulse to be induced at the grid of V2, causing a still greater increase in plate current. This regenerative action quickly drives the tube to full conduction. The duration of the pulse is determined by transformer characteristics, as described in the following circuit. The time constant in the blocking-oscillator grid circuit has been kept low to permit rapid recovery after a pulse. Capacitor C2 bypasses the bias supply directly to the cathode to remove the cathode resistor from the



grid current path. This prevents changes in load at the cathode output from affecting pulse width.

Output may be taken from the third transformer winding or at the cathode. Either polarity is available from the transformer winding; output at the cathode is positive. Resistor R8 may be used to prevent ringing or oscillation.

The trigger amplifier V1 prevents the blocking oscillator from reacting on the trigger source. A disadvantage of this type of triggering (called "parallel-triggering") is that the delay between trigger and output pulse is increased. This delay results from using the transformer as a coupling element for the trigger, and can be shortened by triggering the grid directly (series-triggering) using a cathode-follower input stage. There is considerable reaction on the trigger source, however, despite the cathode follower, because of the heavy grid current.

Input: 30-v minimum amplitude, 100-v-per-usec minimum rise time.

Maximum duty factor: 0.05.

Output pulse width: 0.1 to 2 usec, determined by transformer.

Output rise time: 0.05 to 0.25 usec, open circuit.

Output amplitude: 20 v open circuit.

Delay between input and output: 0.2 usec.

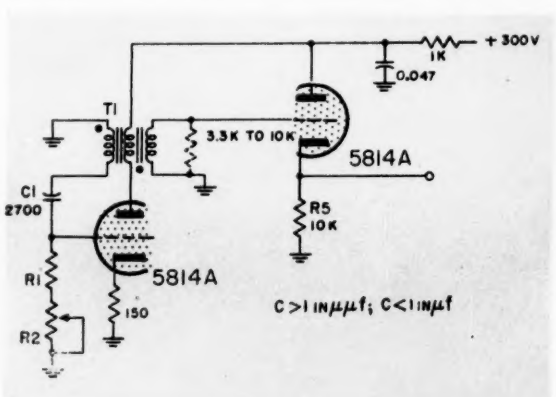
Source: NavAer 16-1-519, *Handbook of Preferred Circuits, Navy Aeronautical Electronic Equipment*, Bureau of Standards, Washington, D. C.

BLOCKING OSCILLATOR FOR PRF OF 200-2000 PPS

Blocking oscillators are used widely to generate high-amplitude pulses. This free-running blocking-oscillator is used as a pulse-repetition-frequency (PRF) generator in applications where frequency stability need not be better than ±5%. Circuit is NBS-BuAer Preferred Circuit PC48A.

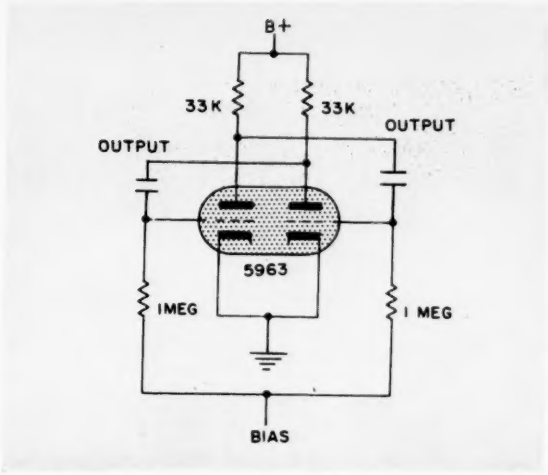
Half of a type 5814A dual triode tube is the blocking oscillator tube; the other triode section is used as a cathode-follower output amplifier to minimize the effect of load on pulse repetition frequency.

Operation is as follows: When power is initially applied to the circuit, the left-hand stage begins to conduct. Current flow in the plate winding of transformer T1 induces a voltage in the grid winding. Windings are polarized so that the induced grid voltage is positive; this regenerative action reinforces the flow of plate current, quickly causing the tube to reach full saturation current flow.



CIRCUITRY

The circuit is the heart of all electronics. Here are 4 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.



During this pulse-time, grid current flows, charging capacitor C1 to about 150 v. After a time (T) determined by the transformer self-resonant frequency, the voltage across grid winding drops to zero. The voltage left on the grid capacitor then drives the grid highly negative, cutting the tube off. Grid voltage then rises exponentially toward ground as the charge leaks off C1 via resistors R1 and R2. Eventually the grid voltage rises to the cutoff value, and the tube again conducts; the cycle then repeats.

The output pulse is developed across the third transformer winding, which is polarized for positive pulse output. Gain of the cathode follower is 0.9. The cathode follower stretches out the fall time of the pulse; if less amplitude is acceptable, fall time may be improved by reducing the value of the cathode resistor R5.

Pulse duration is determined primarily by pulse transformer characteristics; it may be affected by capacitor C1. The pulse frequency (PRF) is determined by the RC product in the grid circuit, the initial grid voltage at the start of the timing interval, and the cutoff voltage of the tube. Values of R1 and R2 are best determined experimentally; R2 should be large enough to permit the PRF to be changed about 40% to accommodate different tubes. Temperature-stable RC components should be used.

The PRF changes about 1% with a 10% change in plate supply voltage or with a 10% increase in filament voltage. A decrease in filament voltage may produce twice the change in frequency. Changes in tube characteristics during the life of a tube have little effect on frequency; differences from tube to tube are substantial, as indicated above.

Pulse repetition frequency: 200 to 2000 pps.

Frequency stability: ±5%.

Pulse width: 0.1 to 5.0 usec, determined by transformer.

Rise time: 0.05 to 0.5 usec, determined by transformer.

Output amplitude: 100 v open circuit.

Output impedance: 400 ohms approx.

Source: NavAer 16-1-519, *Handbook of Preferred Circuits, Navy Aeronautical Electronic Equipment,* National Bureau of Standards, Washington, D. C.

MULTIVIBRATOR

This multivibrator generates a square or rectangular wave output at rates up to 100 kc; may be free-running or synchronized by negative pulses into either grid. Frequency is determined by value of capacitors coupling each plate to the opposite grid, or by d-c voltage applied to bias pin, the latter also providing fine frequency control.

Output: 170-v p-p into minimum load resistance of 200,000 ohms.

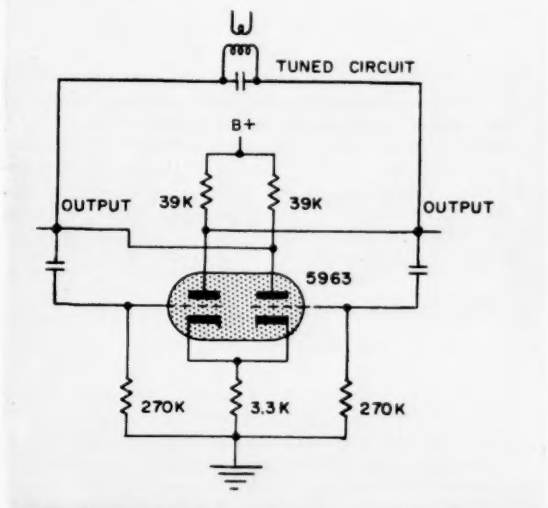
Sync signal: Negative pulse 15-v p-p minimum.

B Supply: 200 v at 2 ma.

Source: Circuit Z-90036, EECO Production Co., 827 S. Vermont Ave., Los Angeles 5, Calif.

AUDIO OSCILLATOR

A multivibrator with tuned tank between the plates gives sinewave output with low harmonic content. Coupling capacitors of 100 uuf are used for 3-5 kc operation; lower frequencies require larger capacitance.



Output: Amplitude depends on plate supply; 150-v supply produces 43-v p-p output; 200-v supply produces 65-v p-p output. Output has approx. 3% third-harmonic distortion at plates; 1% total harmonic can be realized by taking output from secondary of external tuned transformer with Q of 100 or better.

B Supply: 150 v at 3 ma.; 200 v at 4 ma; frequency changes 0.1% with change in B supply from 150 to 200 v.

Source: Circuit Z-90019, EECO Production Co., 827 S. Vermont Ave., Los Angeles 5, Calif.

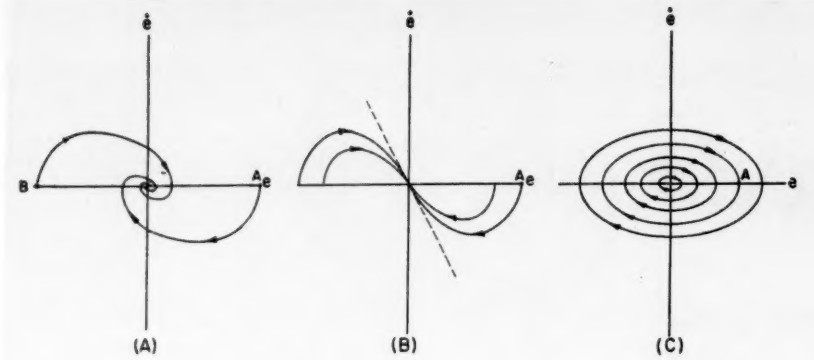


Fig. 1. Phase-plane representation of linear system behavior; (A) small damping; (B) large damping; (C) no damping.

Basic Analysis Methods for

Basic methods for analysis of nonlinear control systems include the phase-plane method, the describing-function method, numerical integration techniques, equivalent (graphical) methods, and step-by-step techniques. The phase-plane and describing-function methods, which are discussed in detail, do not require exhaustive preliminary investigation. The extensive bibliography is also of high value.

IN a linear system, a unit step function is an adequate test input, since every other input can be approximated as closely as desired by a succession of steps and the response calculated as a super-position of unit step-response curves, properly scaled in magnitude and positioned in time. In similar fashion, frequency-response tests with sinusoids of a single amplitude are sufficient; in fact, the frequency response can be calculated from the step response.

PHASE-PLANE METHOD OF ANALYSIS

The phase plane, whose coordinates are usually the system *error* and *error rate* (Fig. 1), provides both a means for representing pheonomena in nonlinear systems and a means for detailed analysis of such systems. If the system is described by a second-order differential equation, and if the input is a step or ramp function, the state of the system at any time is completely specified by a point in the phase plane. A succession of such points, joined by a continuous curve to show the history of the system, is called a *trajectory*.

In the examples which follow, we assume that the trajectories are known, either by experiment or calculation. We adopt this approach to focus attention on use of the phase plane and the information that can be obtained from it. The real value of the phase-plane method lies in the fact that trajectories showing system behavior can be constructed even when the variables cannot be found directly as functions of time.

The following examples concern a positioning servomechanism with an output member characterized by inertia (J) and viscous friction (f). The torque used to position the output member is, in general, a nonlinear function of the error between the desired and actual positions of the output shaft.

1. Linear System

Any method for analyzing nonlinear systems also must work for linear systems, although the converse is unhappily not true. We begin by considering a system in which the torque is proportional to the error. The torque-error relation is expressed in this case by the single equation.

$$T = K\,e \qquad (1)$$

The system trajectories have the possible forms shown in Fig. 1. We suppose that the system has been subjected to a step input and starts at point A. If the system damping (proportional to f) is small, the error reaches zero in an oscillatory manner, shown by the spiral trajectories of Fig. 1 (A). If the system damping is large, the error decreases to zero without overshoot, as shown in Fig. 1 (B). If the system damping is zero, continuous oscillations occur; the system returns to its starting point on a closed elliptical trajectory, as shown in Fig. 1 (C).

Since the positive error rate always corresponds to an increasing error and a negative error rate to a decreasing error, the arrows along the trajectories always point to

Contributed by the Instruments and Regulators Division for presentation at the ASME-IRD Conference, Princeton, N. J., March 26-27, 1956. An abstract of Paper 56—IRD-9.

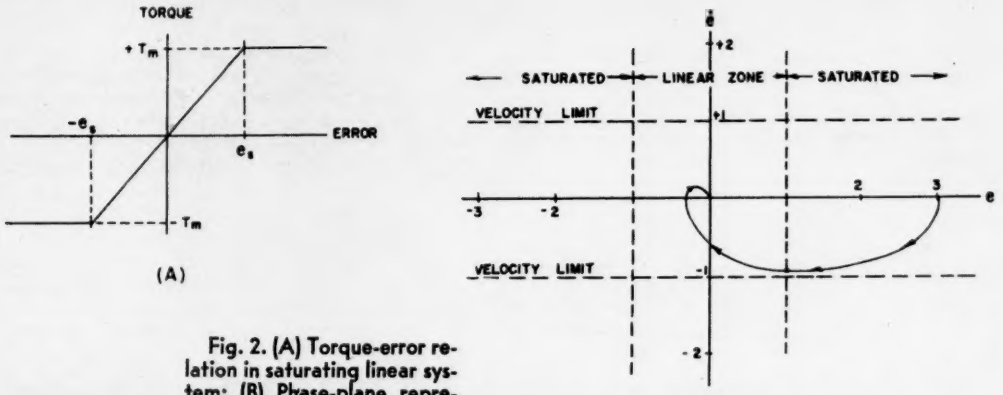


Fig. 2. (A) Torque-error relation in saturating linear system; (B) Phase-plane representation of step response.

Nonlinear Control Systems

T. M. STOUT
Schlumberger Instrument Co.

the right in the upper half of the plane and to the left in the lower half.

This system is stable for all parameter values (except $f \leqslant 0$) since all trajectories end at the origin, and the steady-state error for step inputs is zero. Because the system is linear, trajectories for other step magnitudes can be drawn by a simple scaling process, expanding or contracting the given trajectories to pass through the specified initial point.

2. Saturating Linear System

The system considered in the first example becomes nonlinear if the torque becomes constant ($\pm T_m$) whenever the absolute error exceeds a certain value (e_s), as indicated in Fig. 2 (A). The torque-error relation is now given by three equations

$$\begin{aligned} T &= +T_m \text{ for } && e > e_s \\ T &= Ke \text{ for } -e_s < && e < e_s \\ T &= -T_m \text{ for } && e < -e_s \end{aligned} \qquad (2)$$

The phase plane likewise may be divided into three regions—a linear region bounded by the lines $e = \pm e_s$ and two saturated regions. In the linear region, the trajectories have the possible shapes of Fig. 1, the exact shape depending on the parameters of the system. In the saturated regions, the trajectories approach a limiting error rate: $\dot{e} = \pm T_m/f$.

A typical trajectory, obtained by fitting together trajectories appropriate to the respective regions, is shown in Fig. 2(B) for the case $T_m = J = f = e_s = 1$. The system is again stable and all trajectories will end at the origin. Since the trajectories cannot enter the linear region with an error rate greater than the limiting rate, the overshoot cannot be much greater than shown, about one third of a unit for a three-unit step input.

3. Relay System

If e_s in the previous system is made smaller and smaller by increasing K, the system becomes effectively a relay system in which the torque-error relation is

$$\begin{aligned} T &= +T_m \text{ for } e > o \\ T &= -T_m \text{ for } e < o \end{aligned} \qquad (3)$$

The phase plane is now divided into two parts with relay operations occurring on the dividing line between the two regions, $e = 0$. The trajectory following a four-unit step is shown in Fig. 3. The system is again stable and the maximum possible overshoot is about one-third unit.

4. Relay System with Lead Network

The overshoot exhibited by the relay system can be reduced by use of a lead or rate network, making the torque-error relation

$$\begin{aligned} T &= +T_m \text{ for } e + T_r\dot{e} > 0 \\ T &= -T_m \text{ for } e + T_r\dot{e} < 0 \end{aligned} \qquad (4)$$

The phase plane is divided into two regions by the line

$$e + T_r\dot{e} = 0 \qquad (5)$$

where T_r is the time constant of the lead network. A typical trajectory is shown in Fig. 4 for the case $T_r = 0.2$; the overshoot in this case is about one-tenth unit.

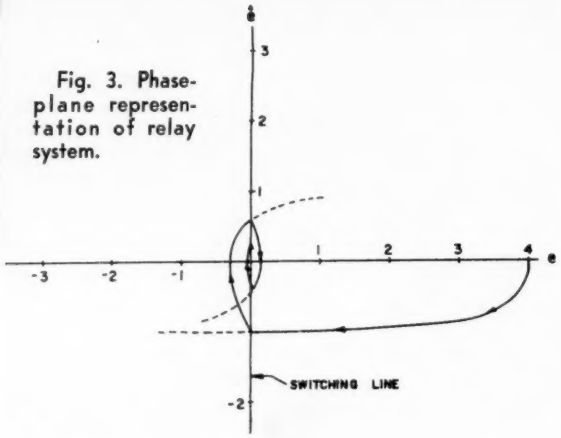


Fig. 3. Phase-plane representation of relay system.

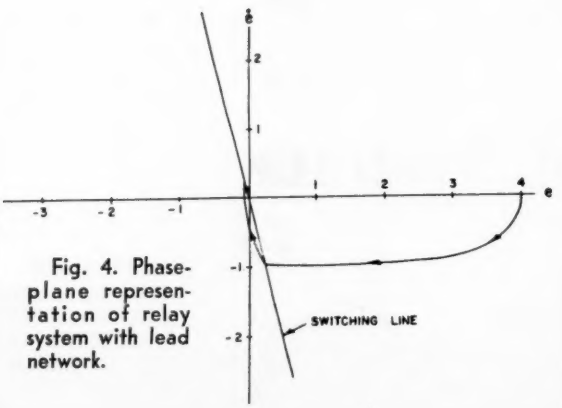


Fig. 4. Phase-plane representation of relay system with lead network.

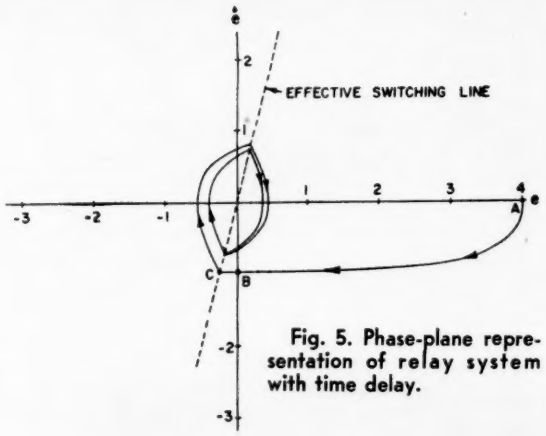


Fig. 5. Phase-plane representation of relay system with time delay.

Overshoot can be eliminated completely by the substitution of a nonlinear relation for the straight line of Equation (5); this observation is the basis for the design of optimum relay servomechanisms which have been discussed extensively (see reference *12* for a partial list of pertinent references).

5. Relay System with Time Delay

Suppose that the relay starts to operate when the error is zero but that torque reversal actually occurs T_d time units later. Since the distance travelled in a fixed time is proportional to the velocity, the effective switching line is as shown in Fig. 5, switching is initiated at point B, but torque reversal does not occur until the trajectory reaches point C. The system is now unstable; with all trajectories ending in a closed curve or "limit cycle." The amplitude of the limit cycle in this case is about one-third unit; the period of oscillation is not available directly but turns out to be about 3.7 time units.

6. Relay System with Dead Zone

In this case, we suppose that a finite error signal is needed to operate the relay but that relay operation is instantaneous. The torque-error relation is therefore

$$\begin{aligned} T &= +T_m \text{ for } e > e_d \\ T &= 0 \text{ for } -e_d < e < e_d \\ T &= T_m \text{ for } e < -e_d \end{aligned} \qquad (7)$$

The phase plane is again divided into three regions. In the regions corresponding to $+T_m$ and $-T_m$, the trajectories are similar to those of the saturating linear system or relay system (Examples 2 and 3). In the center zone where no torque is applied to the output member, the error rate decreases because of friction losses; the trajectories in this region are straight lines with a slope $-f/J$.

A typical trajectory is plotted in Fig. 6 for the case $e_d = 0.25$; the overshoot is about 0.4 unit and the final error about 0.125 unit. This system is stable in the sense that the error rate eventually reaches zero; there is, however, a steady-state position error less than or equal to e_d.

Comments

The phase-plane method is suitable for transient analysis of systems described by a single nonlinear differential equation of second order, or by a succession of linear or nonlinear differential equations, each applicable in certain ranges of the variables. Several nonlinearities can be considered simultaneously. A phase-plane analysis can be made as accurate as desired and shows the general nature of the system behavior. In addition, the phase-plane plots give a direct indication of the degree of damping or amount of overshoot and the amplitude of any sustained oscillations which may occur.

The times associated with each point on a trajectory, needed to find the response time for step inputs or the period of any sustained oscillations, are not directly available; they can, however, be computed from the relation:

$$t_{AB} = \int_{e_A}^{e_B} (1/\dot{e})\, de \qquad (8)$$

or by a graphical construction due to Diprose.

A unique relation between the system trajectories and the phase-plane coordinates exists only for second-order systems subjected to step or ramp inputs. The behavior of a second-order system with more general inputs can be computed by generalizations of the basic phase-plane techniques and recorded in the error-and-error-rate plane. For higher-order systems, a phase space is required; projections of phase-space trajectories into the error-error rate plane may still be useful.

DESCRIBING-FUNCTION METHOD

The describing-function method rests on the work of Fourier and parallels techniques used for some time in the field of nonlinear mechanics. As a method for analysis of nonlinear control systems, it seems to have been devel-

oped independently and almost simultaneously by Tustin in England [15], Goldfarb in Russia[16], Oppelt in Germany[17], Dutilh in France[18], and Kockenburger in the United States[19]. Numerous extensions and applications of the basic idea have been made in the last few years.

The describing function for a nonlinear element is found by applying a sinusoidal input to the element and, using standard Fourier analysis techniques, determining the fundamental component of the distorted output. The describing function has two parts; (a) the output-input amplitude ratio, computed from the peak values of the fundamental output component and the sinusoidal input; and (b) the phase shift between the sinusoidal input and the fundamental output component. For the examples used in this paper, the phase shift is zero. For elements which are completely described by a curve relating the instantaneous input and output, the describing function depends on the magnitude of the input but is independent of its frequency.

The describing function for a saturating linear element is shown in Fig. 7. For inputs less than x_s, the describing function is K, the slope of the output-input curve. For larger inputs, the output magnitude is limited and the describing function decreases.

Use of describing functions is based on the block diagram shown in Fig. 8. For checking stability, we can assume the input (r) is zero. The condition for the existence of a sustained oscillation is

$$e = -c \tag{9}$$

which requires that

$$G_1 G_d G_2 = -1 \tag{10}$$

or

$$G\ G_D = -1 \tag{11}$$

if we let $G = G_1\ G_2$. In these equations, G_1 and G_2 represent ordinary linear gain functions which are independent of amplitude but dependent on frequency, and G_D is the describing function for the nonlinear element, the nonlinear torque-error relation.

To check for the existence of sustained oscillations, we will write Equation (11) in the equivalent form

$$G = -1/G_D \tag{14}$$

We then plot G and $-1/G_D$ as separate curves in a standard polar plot, showing the magnitude and phase of each quantity. Intersections of the two curves, if any exist, give the approximate magnitude and frequency of possible sustained oscillations. Further analysis is required to determine whether the intersections are points of convergent or divergent equilibrium[19].

Example 1. Linear System

If there is no saturation, the torque-error relation is simply $G_D = K$. The curve $-1/G_D$ becomes the point $-1/K$. As shown in Fig. 9, $G(\omega)$ is infinite and has a phase angle of $-90°$ at zero frequency, and approaches zero with a phase angle of $-180°$ at infinite frequency. As is the case with the usual Nyquist criterion, the system is stable since the curve $G(\omega)$ does not enclose the critical point $-1/K$, regardless of the value of K.

Example 2. Saturating Linear System

Fig. 7 indicates that saturation causes G_D to become less than K when the input to the saturating element is large. Thus $1/G_D$ is always equal to or greater than $1/K$, and $-1/G_D$ occupies the entire negative axis of the polar plot to the left of the point $-1/K$, as shown in Fig. 9. The system is stable under the conditions shown. It could exhibit sustained oscillations if K were increased and if additional phase lags, indicated by the dashed line, were introduced.

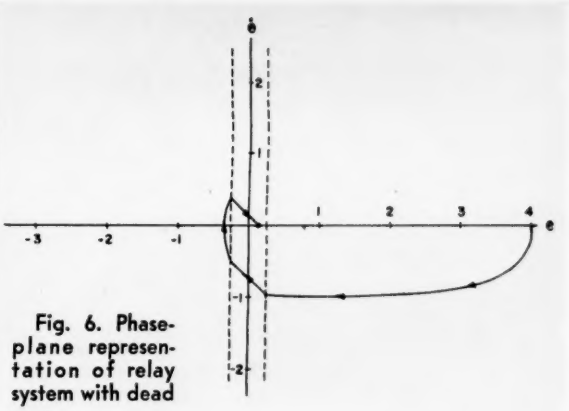


Fig. 6. Phase-plane representation of relay system with dead zone.

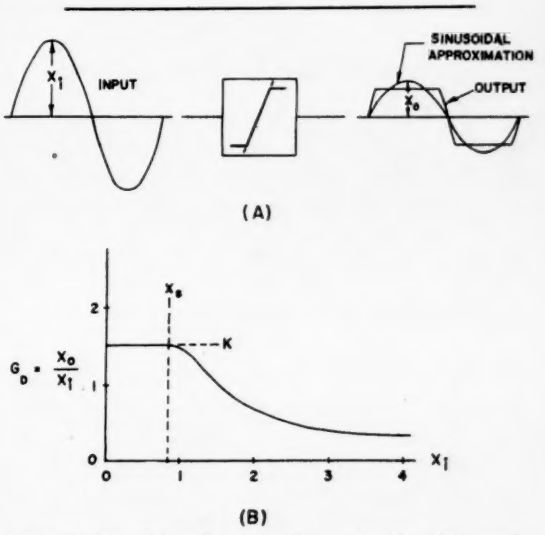


Fig. 7. Describing function for saturating linear element.

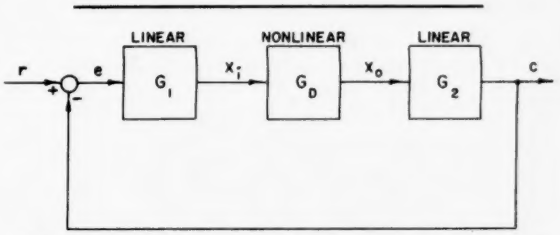


Fig. 8. Block diagram of control system with a nonlinear element.

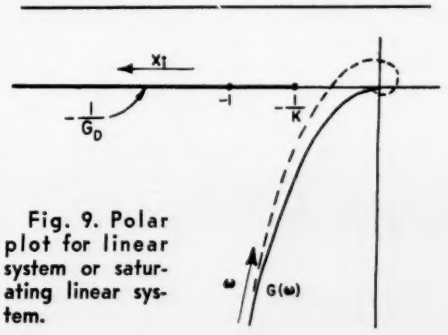


Fig. 9. Polar plot for linear system or saturating linear system.

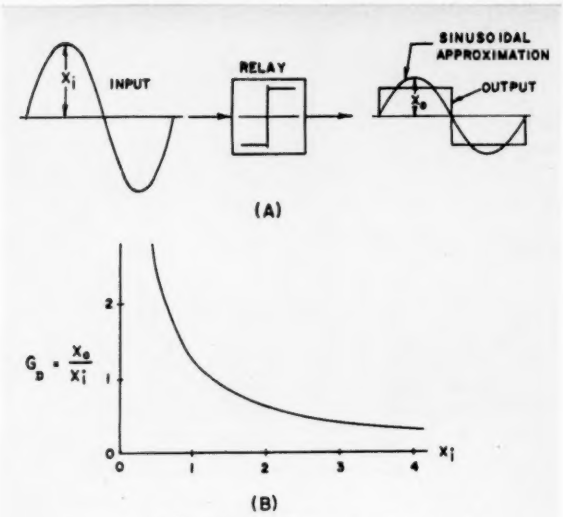


Fig. 10. Describing function for ideal relay.

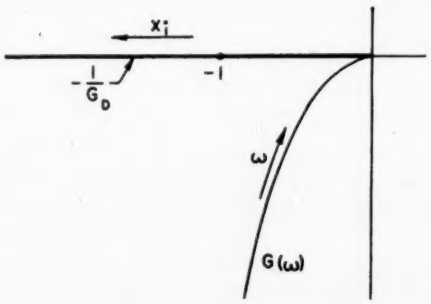


Fig. 11. Polar plot for system with ideal relay.

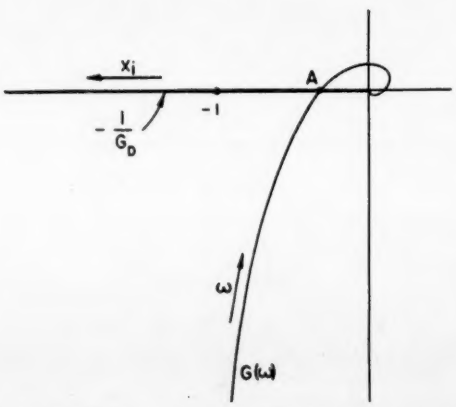


Fig. 12. Polar plot for system with ideal relay and time delay.

Example 3. Relay System

The calculation of the describing function for an ideal relay is based on Fig. 10(A). Since the relay is assumed to have no dead zone the relay output is a square wave for a sinusoidal input of even infinitesimal amplitude. Since the fundamental component of a square wave is $(4/\pi)$ (peak values), D_D is a constant divided by X_i, giving the hyperbola plotted in Fig. 10(B). Since G_D now ranges from zero to infinity, $-1/G_D$ occupies the entire negative axis of the polar plot, as shown in Fig. 11. For the $G(\omega)$ considered in these examples, the system is stable; with any slight additional phase shift, sustained oscillations would take place.

Example 4. Relay System with Time Delay

Addition of time delay to the relay system can be represented by adding a phase shift proportional to frequency to $G(\omega)$, giving the curve shown in Fig. 12. The curves $G(\omega)$ and $-1/G_D$ intersect at Point A, indicating the possibility of a sustained oscillation. In terms of the usual Nyquist criterion, all points on $-1/G_D$ between A and the origin are enclosed by the curve $G(\omega)$, so that the system is unstable in some sense for the small X_i amplitudes associated with G_D in this range. In similar fashion, the system is stable for points on $-1/G_D$ to the left of A which are not enclosed and which correspond to large X_i amplitudes. Point A is therefore a convergent equilibrium point, since large amplitudes decay to A and smaller ones grow to A. Following any slight disturbance, this system will therefore oscillate with the approximate frequency and amplitude associated with point A.

Comments on Describing-Function Technique

The describing-function method gives a direct indication of the existence, amplitude, and frequency of possible sustained oscillations. In general, the errors in the predicted amplitude and frequency are not more than 10%.[19] This accuracy is probably consistent with the original data and adequate for most engineering purposes. On the other hand, the describing-function method is inherently an approximate method and may therefore fail occasionally to predict a sustained oscillation which actually does occur, or may predict one which does not occur.

The proximity of the $-1/G_D$ and $G(\omega)$ curves gives a rough idea of the relative stability of the system and thus provides a very qualitative indication of the transient response to be expected. The curves also can be used to construct approximate frequency-response curves for the system; unlike the linear case, the output-input ratio is a function of amplitude as well as frequency.

In contrast with the phase-plane method, the describing-function method is applicable to systems in which the linear elements are described by differential equations of third or higher order. The effects of various compensation methods (which increase the order of the differential equations) can be examined by making appropriate modifications of the $G(\omega)$ curve, as in the case of linear system design.

Other Methods

A number of other methods, less widely used, also are available for analysis of nonlinear control systems. Most of the methods mentioned in the following paragraphs are useful for determining the response of systems to particular inputs.

Numerical integration techniques, in principle, always can be used if the differential equations can be written.

Many of the numerical methods concern a first-order equation:

$$\dot{x} = F(x, t) \qquad (15)$$

or systems of such equations, although methods also exist for dealing directly with second-order equations. These methods are essentially extrapolation and correction schemes. The simplest procedure is linear extrapolation, using the relation

$$x(t+\Delta t) = x(t) + (\Delta t)\ \dot{x}(t) \qquad (16)$$

The computed value of x can be used to obtain an average $\dot{x}$ in the interval Δt, from which a more accurate value of x can be found. Still better methods are described in texts on numerical analysis[5-7]. These methods are somewhat tedious for hand use but are basic to automatic digital computers.

Equivalent methods in which the integrations are performed graphically (instead of numerically) have been proposed by Hsia[20] and Paynter[21].

A number of *step-by-step* methods combining numerical and graphical techniques have been proposed by Tustin[22], Madwed[23], and Stout[24]. In these methods, the response of a linear element is computed from its input by numerical methods, making direct use of the superposition principle, and the nonlinearity is taken into account by a graphical construction.

Another adaptation of the superposition principle was used by Kahn[25] in a study of relay servomechanisms. Since the system following the relay was linear, its output could be found by superposition of step responses corresponding to the application and removal of a fixed input by the relay. The variables entering elements preceding the relay determine the times of relay operation but do not otherwise affect the system output.

In certain systems, such as the saturating or relay systems used in the examples, operation is governed by a number of linear differential equations applicable in restricted ranges of the system variables. This property, known as "piece-wise linearity," can be used to good advantage in phase-plane analysis and also can be used to construct response curves directly as functions of time. The response for any input is found by joining solutions of the linear equations at transitions from one mode of operation to another. the final conditions for one mode becoming the initial conditions for the next. Hazen[26] investigated the conditions for sustained oscillation in relay servomechanisms using this method, and Nichols[27] recently used the same approach to check the accuracy of a describing-function analysis.

Conclusions

The phase-plane and describing-function methods can furnish answers to many—but not all—of the performance questions which concern the control-system designer. The two methods complement each other, the phase-plane method being useful for second-order systems and the describing-function method for high-order systems. The phase-plane method deals primarily with transient conditions, however, while the describing-function method is concerned with steady-state oscillatory conditions. Extensions of both methods have been and will be devised to remedy these limitations and to increase their usefulness.

A number of other methods are available for nonlinear control-system analysis. Unlike the phase-plane and describing-function methods, these methods reveal general features of system behavior only after exhaustive investigation of all kinds and sizes of system inputs. These methods are therefore better adapted to analysis of specific systems than to system design or modification.

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Fig. 1. Eccentric (upper left) operates Microswitch to produce one pulse for each 0.1-inch travel of probe on lead screw.

Fig. 2. Sequence of transmitted pulses.

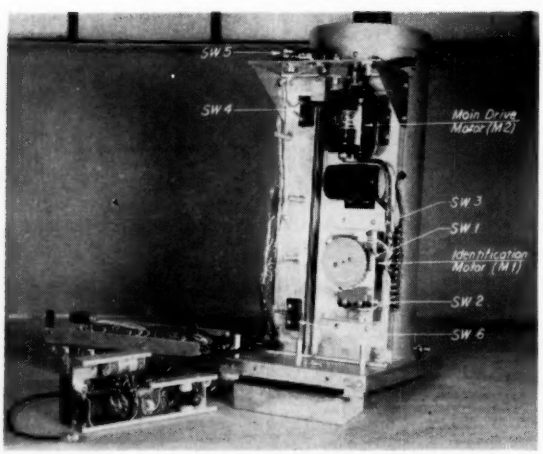

Fig. 3. Catch can with transmitter removed shows duplicate (exterior) lead screw, limit switches, and keying components.

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Acknowledgements

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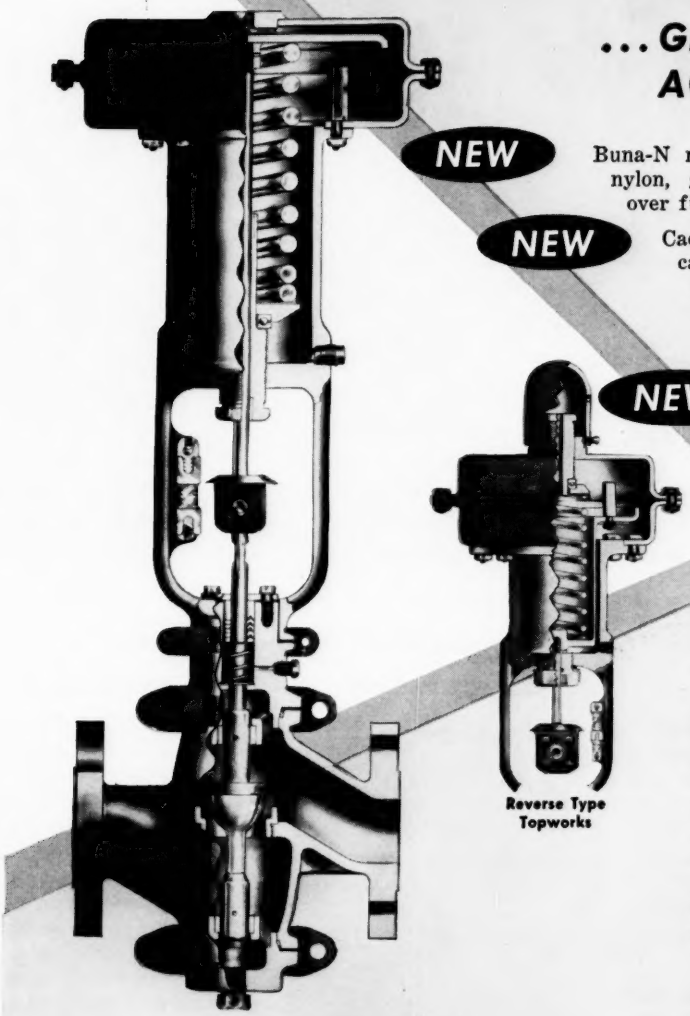

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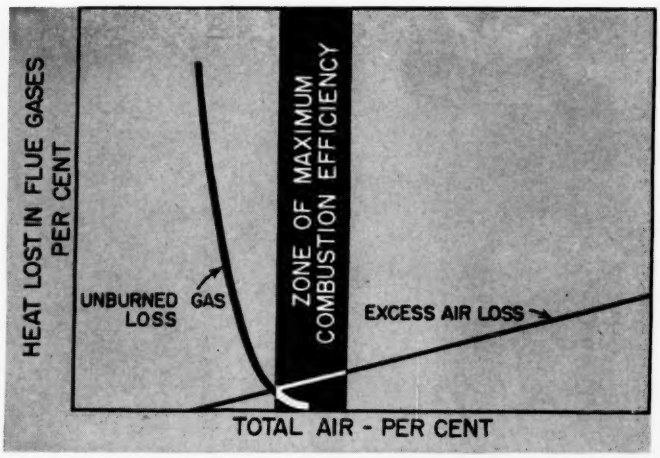
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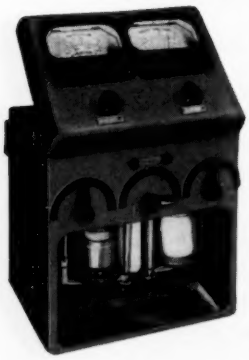

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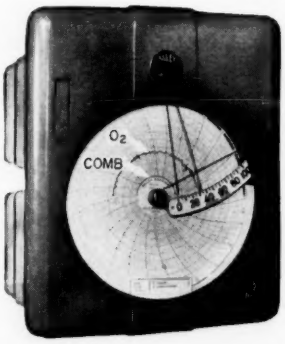

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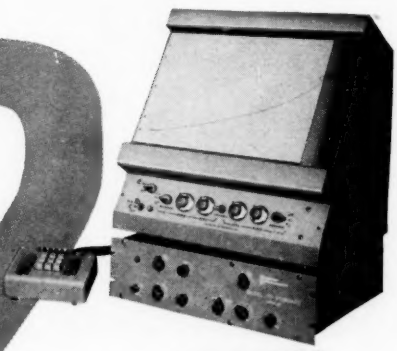


model 200

11x17", flatbed
±0.15% of full scale accuracy
20" per second slewing pen speed
3 scales; 0.1 v, 1.0 v, 10 v per inch
scale and zero potentiometers
with in-line dials
1 megohm input resistance

Shown with Keyboard (Model 175) and Symbol Generator (Model 250)

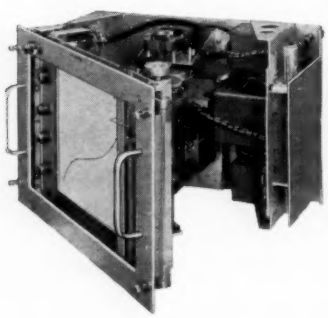
10-key keyboard
six electrically selected characters
complete operational controls

3

model 225

11x17", flatbed
±0.2 full scale accuracy
20" per second slewing pen speed
built-in electronic reference
16 scale ranges, 0.5 mv to 50 v per inch
200,000 ohms-per-volt input impedance

All models available for standard rack mounting. 11x17" instruments may be used in standard cabinet or rack mounted —without changing metalwork!



Accessories include: Curve follower (Model 210), Card-Tape Converter (Model 150), Keyboard (Model 175), and Symbol Generator (Model 250).

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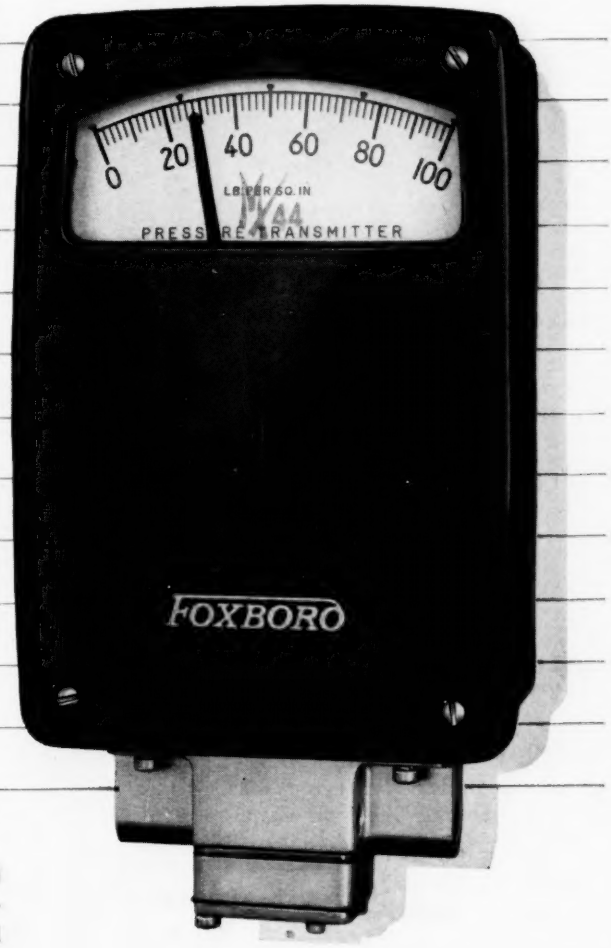
Unique combination of fine engineering and economy!

...the new FOXBORO M/44 INDICATING PRESSURE TRANSMITTER



- **Easier to Read . . . large indicator scale, visible at 20 ft.**
- **Easier to Calibrate . . . simple adjustments "on location"**
- **More Compact . . . single, integral instrument**

Any way you look at it, the new Foxboro M/44 Pneumatic Pressure Transmitter gives you an unmatched combination of fine engineering and economy. First; because it *is* an engineered instrument. There are no attachments or "makeshifts". Second; because it utilizes standard Foxboro parts throughout—parts which have been performance-proved in thousands of successful installations of other Foxboro Instruments. And this means not only top performance, but easier servicing and stocking as well. Third; calibration is simple, right in the field, because the M/44 is "convenience-designed" by men with years of experience in every phase of instrument design and application.

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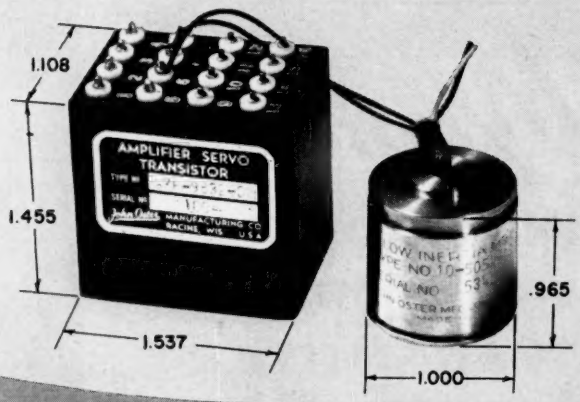
Completely TRANSISTORIZED AMPLIFIER & SERVO MOTOR



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AMPLIFIER DATA

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- Load Impedance: 250 + JO ohms. This is the 400 cycle stall impedance of an Oster Type 10-5054-03 servo motor control phase when resonated with 2.0 microfarad capacitor.
- Power Gain (open loop conditions—no negative feedback): 50 D. B. minimum.
- Power Output: 0.5 watt minimum.
- Power Requirements:
  + 19.5 Vdc—250 ma.
  + 4.5 Vdc— 20 ma.
  + 8.5 Vdc— 6 ma. (regulated ± 5%)
- Amplifier Rating: 0.5 watt min. at 25°C.
- Environment proof operation assured by encapsulation of amplifier assembly.

SERVO MOTOR DATA

- With .015V at 400 cycles applied to amplifier input, motor pinion rotates 5000 RPM minimum under no load conditions.
- With .075V at 400 cycles applied, motor develops .15oz.-in. minimum stall torque. Minimum speed 6200 RPM under no load conditions.
- Up to 0.2 oz.-in. torque can be obtained by energizing the reference phase with 31.0V if motor has an adequate heat sink. This results in a reference phase current of approx. .210 amperes.

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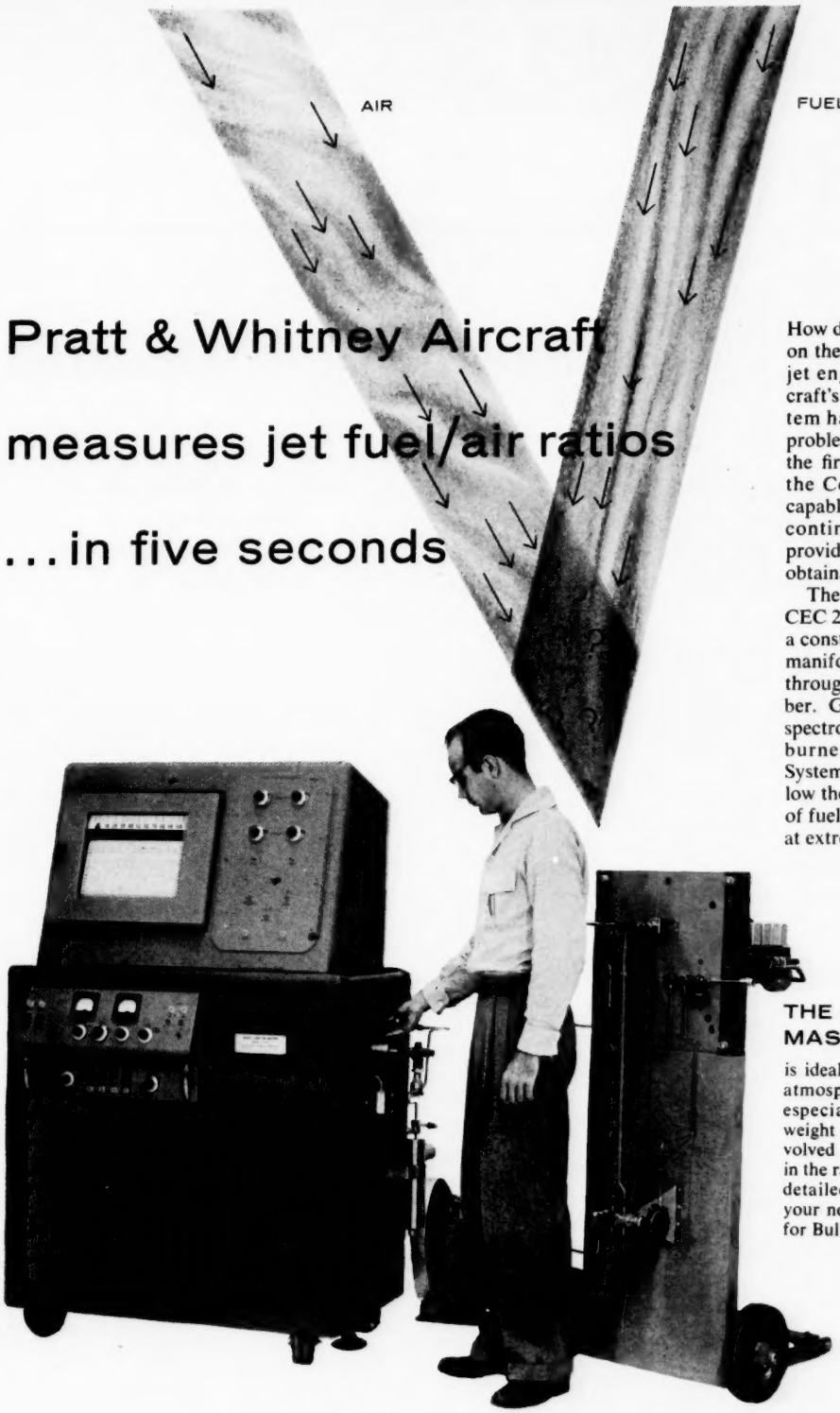

Pratt & Whitney Aircraft measures jet fuel/air ratios ...in five seconds

How do you get rapid, accurate data on the fuel/air distribution within a jet engine? Pratt & Whitney Aircraft's new dynamic sampling system has solved this long-standing problem of the aircraft industry. In the first few minutes of operation, the Consolidated System proved capable of measuring fuel/air ratios continuously and automatically—providing plotted data never before obtainable so rapidly and so easily.

The complete system consists of a CEC 21-620 Mass Spectrometer and a constant-pressure, explosion proof manifold which does the sampling through a probe in the burner chamber. Gas samples reach the mass spectrometer 75 feet from the test burner in five seconds. The CEC System also makes it possible to follow thermal cracking and reforming of fuel components within an engine at extremely high temperatures.

THE CEC 21-620 MASS SPECTROMETER

is ideally suited for process-stream or atmosphere-monitoring applications, especially when higher molecular weight gas or liquid components are involved . . . provides accurate readings in the range of mass 2 to mass 150. For detailed information, please contact your nearby CEC field office, or write for Bulletin CEC 1824-X14.

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Journal of the S C M A . . .

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Two-Range Flow-Rate and

This two-range dual-meter flow rate and totalizing system provides for the remote indication of fuel flow rate and individual totalization of the quantity of fuel. The measuring system automatically selects the optimum range.

HERMAN H. ROSS, JR.
Potter-Pacific
WILLIAM CHRUSCH
Potter Aeronautical

A FUEL flow-rate and totalizing system has been designed around two "Pottermeter" turbine-type flow-rate pickups to provide the following operational features (Fig. 1):

1. The system selects the sensing element and indicator range that permits maximum readability for the rates of flow in use for different phases of a test program. This selection is completely automatic.

2. A *flow-rate converter unit* indicates the rate of flow on a single visual indicator. The same visual indicator is used for both Pottermeters and the range used is determined by the automatic selector. Colored lights are used to indicate both the range being displayed on the visual indicator and the totalizer operation.

3. A *totalizer unit* indicates the total quantity of fluid that has passed through each Pottermeter. This total

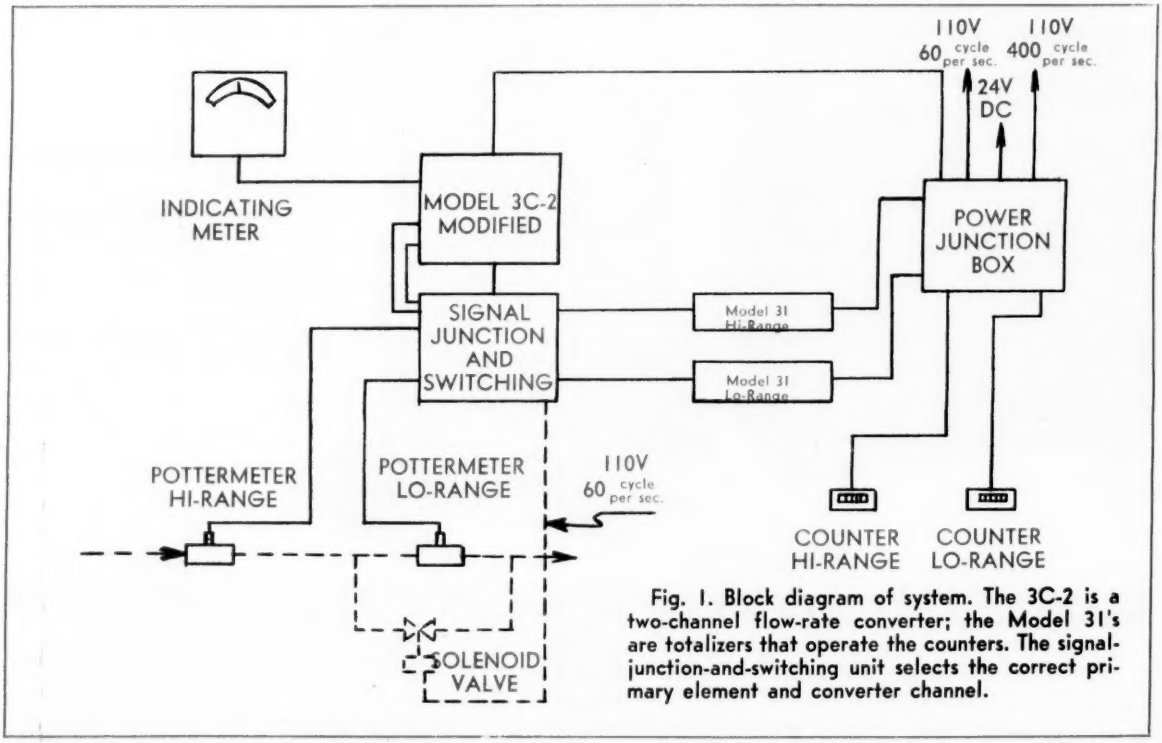
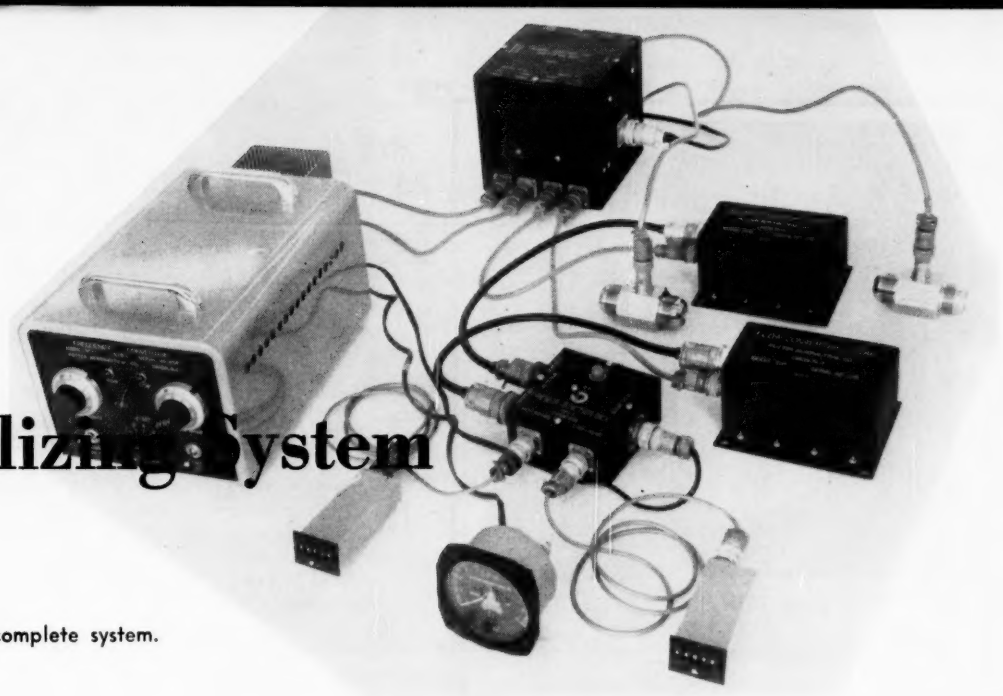


Fig. 1. Block diagram of system. The 3C-2 is a two-channel flow-rate converter; the Model 31's are totalizers that operate the counters. The signal-junction-and-switching unit selects the correct primary element and converter channel.



Totalizing System

Fig. 2. The complete system.

is indicated on remotely located mechanical registers.

4. The system accuracy for flow rate readings is ±1% (all that is necessary as the rate adjustment need be only approximate to set the flow system levels; the system is capable of better accuracy if a more accurate visual indicator is used). As the *total volume* of fuel through each meter is the variable of particular interest in this test installation, the accuracy of this reading must be ±0.5% of the total indicated value.

System Operation

Fig. 1 is a block diagram of the system, designed by the Potter Aeronautical Corporation to meet the measuring and indicating requirements for this special test program. The system consists of standard Potter components, modified and integrated into a complete system package by the Systems Engineering Group at the Union, New Jersey facility.

Two Pottermeter sensing elements are arranged in series, with the low-range element being protected by a solenoid-actuated bypass valve. The signal to actuate the bypass valve is supplied by the *signal junction and switching unit*, which receives the data from the two Pottermeters, and routes it to the proper end indicating instruments.

The signal that controls the routing is developed in the signal junction and switching unit, based on the signal output of a 3C-2 converter. The signal junction and switching unit also supplies the range-change control signal to the 3C-2 range selection relay and the flow signal information to the appropriate Model 31 flow totalizer.

Signal Junction and Switching Unit

The signal junction and switching unit is the logic and main control point of the system. It is a specialized item that was developed for this system but, when utilized with the modified 3C-2 unit, would be satisfactory for many indication and control applications.

The "heart" of the logic unit is a meter-type relay of 1-milliampere sensitivity, with provisions for high- and low-current contacts. Two slave relays are used to actuate a latching relay which does the actual switching of the external circuits. The latching relay also provides the contacts for operation of the solenoid-actuated bypass valve. As used in this system, it:

1. Selects and distributes the flow signal information from the two Pottermeter sensing elements (including shorting the input of whichever Model 31 totalizer is not active).
2. Selects the correct state for the range-change relay in the Model 3C-2 flow-rate converter.
3. Provides the necessary interlocking and switching to prevent unwanted and incorrect indications.

These functions are determined by information received from the 3C-2 flow rate converter. The power required for the operation of the signal junction and switching unit is also derived from the 3C-2 unit.

Flow Totalizers

The Model 31 flow totalizers are essentially pulse counters and have an output relay that closes once for every 32 pulses received at the input. The relay circuitry, as a result of the scale-of-32 step down, operates a mechanical register well within the register capacity to achieve positive and reliable operation.

The Model 31 totalers were designed for airborne applications and require 400-cycle 110-volt ac and 28-volt dc for operation. The counters are also operated from 28-volt dc. Similar systems can be designed for operation from 60-cycle 110-volt ac sources.

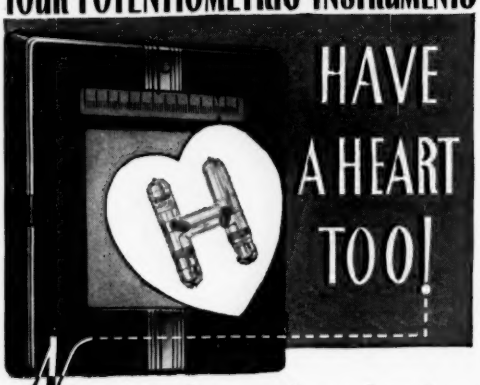
Flow-Rate Converter

The major component of the system is the 2-channel Model 3C-2 flow rate converter. The converter transforms

March Meeting: *Thursday, the 21st, Rio Hondo Country Club, Downey, Calif.*

Feature: *John Illish and Howard Gee, Time Equipment Div. of IBM Corp., will present a paper on "Automatic Production Recording."*

YOUR POTENTIOMETRIC INSTRUMENTS



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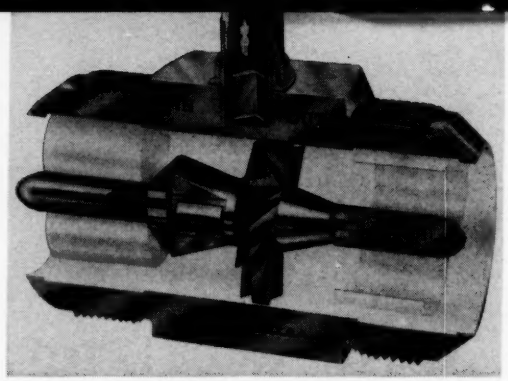


Fig. 3. Cross-section of one of the two pickups. The output is an a-c signal whose frequency is a linear function of flowrate.

the input a-c signal from the pickups into a direct current that is proportional to the a-c frequency. The full-scale input frequency range of the unit is 50 to 3200 cps, selectable in 6 ranges. The output direct current is proportional to, and a linear function of, the input a-c frequency and delivers 0-1 ma into a 100-ohm external load.

The unit normally is supplied with a manual selector switch which selects the input channel and range adjustment to be used. Each input channel is provided with a separate range adjustment potentiometer to permit individual span adjustment to accomodate the sensing element in use.

The modifications made to the 3C-2 for automatic operation were as follows: The channel selection switch was replaced with a relay (operated by a signal from the signal junction and switching unit); pilot light indicators were added to provide a visual indication of what channel is in use; a spring return manual overide switch was included to permit the operator to overcome the automatic operation for independent channel calibration of each channel.

Sequence of Operation

At the initial state of the system, the 3C-2 unit is in the low-range channel position, the bypass is closed, and the signal from the low-range Pottermeter is supplied to the 3C-2 flow-rate converter and the low-range Model 31 flow-totalizer and counter. The indication on the visual meter is a direct current proportional to the fluid flow rate. The mechanical register trips one count for every 32 pulses from the Pottermeter.

As the flow rate increases in accordance with the test requirements, the d-c output current on the visual meter increases proportionally. When the output current value reaches 0.95 ma the high-current contact in the meter-relay in the signal junction and switching unit initiates the necessary relay closures to transform the system operation to the high-range phase.

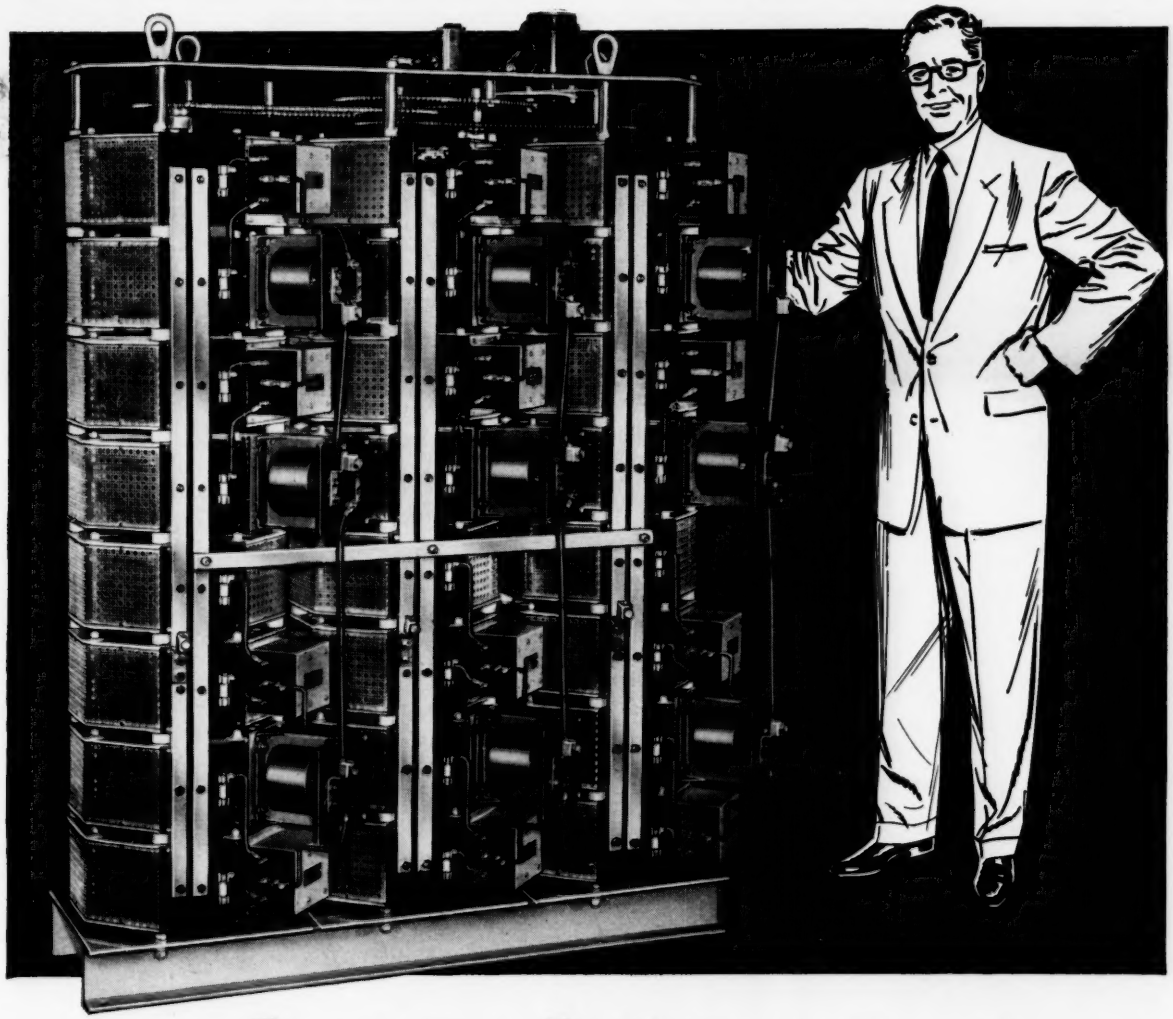
At the initiation of the switch-over, the latching relay signals the bypass valve to open, shorts the signal input to the low-range Model 31 and counter, switches the 3C-2 to the high-range channel, and supplies the flow signal from the high-range Pottermeter to the high-range Model 31 totalizer and counter.

When the flow rate drops to a point where the indicated direct current is less than 0.15 ma, the unit automatically shifts back down to the low-range phase of the system operation.

The power distribution box shown in Fig. 1 acts as a junction point for the supply voltages and as a master power switch.

The Model 3C-2 unit and signal-junction-and-switching unit could be used together without the flow totalizing equipment.

POWERSTAT® Variable Transformers



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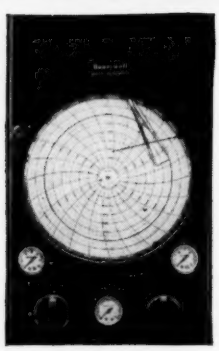

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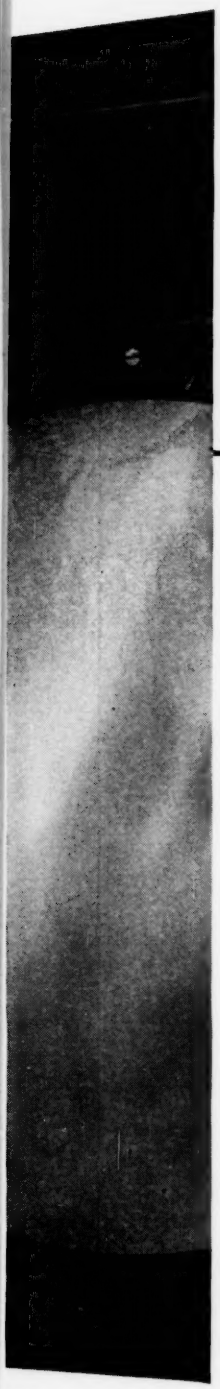

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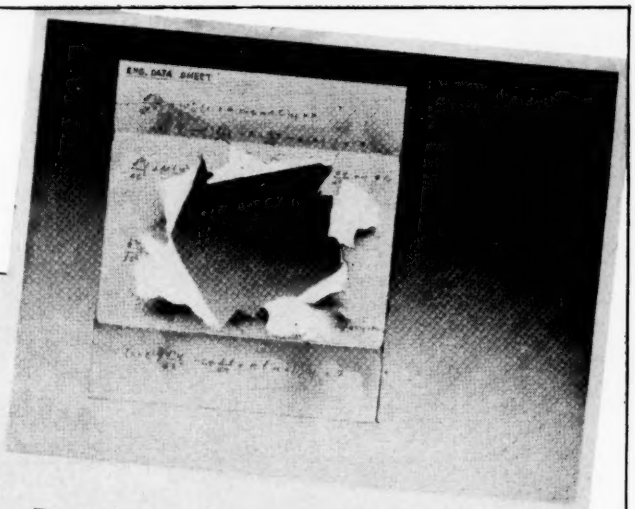

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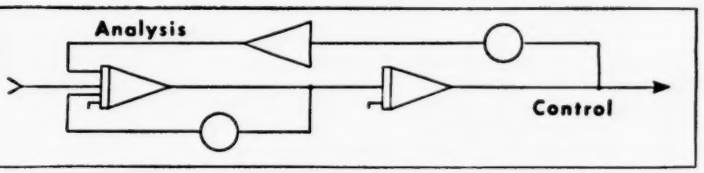
The SIMULATION COUNCIL Newsletter



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Bits

Not much space for Ye Ed to put in his two-bits' worth this month—too much worthwhile stuff.

We have some goings-on at the International meeting in New York concerning "Computers of the Future," and E. G. Holmes' story of the Southeastern Simulation Council meeting on "Error Analysis" and the use of DDA's in connection with analog computers.

Then in "Information" a few words concerning the organization that makes this *Newsletter* possible and some "Allied Operations".

Pieces

REPORT ON FIRST INT'L S/C MEETING AT TIAE

Approximately 80 people attended each of the four sessions of the First International Simulation Council Meeting, held in connection with the Third International Automation Exposition in New York City the last week in November, 1956. Allowing for the fact that all people did not attend all sessions, total attendance must have been about 120.

The first session, Wednesday afternoon, November 28th, was conducted by the Midwestern Simulation Council. Talks and discussion on "Which Computer to Use—Analog or Digital?" will be written up by Bob Lowry, the Midwestern Secretary, and reported in the *Newsletter* when we get the word from Bob.

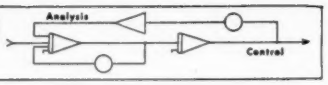
What Next in Analog Computers?

The second session, held later that afternoon, was conducted by the Western Simulation Council. Jack Sherman (Lockheed Missile Systems Division, Palo Alto, Calif.) presided while Ye Ed. (Convair-Astronautics) presented a paper by his absent colleague Stan Rogers (Convair-San Diego) entitled "What Next in Analog Computers?".

Stan's paper—too long to reprint here—was based both on a consideration of what is needed and a knowledge of what is being done. The increase in multishift operation, dictated by economic considerations, Stan believes, is going to exert a strong influence on the development of computers. Therefore increased effort will be devoted to the problem of removing, storing, reinstating, and checking out problems on the equipment quickly and accurately. This will require automatic setup and checkout, which in turn require some means of automatic patching, potsetting, and checkout. Automatic potsetting is well within the state of the art, and several systems of automatic checkout are reasonably satisfactory; however there are no satisfactory means for automatic patching within sight.

Stan feels that the system "should set up the complete problem virtually instantly; that is, it should be a parallel device rather than a perforated tape that has to be read serially. A very desirable form for problem storage would be something like a set of sheets of perforated paper."

It is likely that such mechanization will require some sacrifice of flexibility, but Stan calls for greater flexibility: "To make efficient use of a



large analog computer, the operating stations should not be of fixed sizes . . . it should be possible to control the required number of amplifiers, multipliers, comparators, etc., for one problem from one station. This means . . . that whatever is substituted for the patchboard should be of variable size . . . a large computer should have several operating stations . . . precautions will have to be taken to keep two operators at different stations from trying to use the same computing equipment at the same time."

Stan predicts an increased use of "subroutines" to alleviate the conflict between convenience and complexity. A subroutine would select the components and make all connections to set up frequently-used circuits (as simple as a division circuit or as complicated as a set of standard aerodynamic equations). The operator then would be concerned only with connecting the inputs and outputs and adjusting the constants.

Also needed, Stan says, is some way of helping the operator with his scaling so that he can avoid both overloading and working too near the noise level. *Sed Atwood* (Convair-San Diego) has proposed a method of scanning with a CRT which will indicate these conditions, but a method of preventing or automatically correcting them is needed.

And, analog computers should be better suited for the solution of partial differential equations and the presentation of the results. "We believe that we at Convair are making progress," but much is still to be done.

The marked trend to combined systems also should be considered, Stan reminds us. Therefore "the analog computer of the near future should be planned to be compatible with analog-to-digital and digital-to-analog converters like the the Addaverter."

"A final area", said Stan in closing, "in which large developments should take place in the next two or three years is that of the generation of functions of two or more variables. What is needed here is a convenient method of setting up the desired function, good repeatability, and reasonably good accuracy and frequency response."

In the discussion which followed Stan's paper, *Jules Lehmann* (RCA Laboratories, Princeton, N. J.) disagreed with Stan on one point—that input-output devices should be parallel—and pointed out that 10 to 20 characters per second don't take very long serially; the necessity for going to parallel operation doesn't really seem to be there. He went on to say that a system RCA investigated for the Air Force had connection instructions stored on punched tape. Relays made the connections.

McLeod: "I understand that for any fair-sized computer you would have a barnful of relays."

Lehmann agreed that you would. For 500 amplifiers there would be between 50,000 and 100,000 relays.

Ed Massell (Electronic Associates, Inc., Long Branch, N. J.) commented that a patchboard with a couple of thousand holes has a lot of possibilities. Equivalent flexibility might require several billion relays.

Jules replied that there is a certain logic you have to follow to reduce the number.

A. J. Zeichner (Sylvania Electric Co., Waltham, Mass.) wanted to know which multiplier Stan referred to when he wrote: "The newest electronic multiplying equipment that we have received appears to be clearly superior in accuracy and stability to some of our older equipment."

McLeod 'lowed as how it must be EA 'cause "There are more EA people here than any other vendors!"

Changing the subject, *Jack Sherman* observed, "This question of using subroutines to set up frequently-used circuits brings up the question of when is it wise to use human labor instead of complicated automatic systems."

McLeod asked, "Don't you agree that in aerodynamic problems there is a great similarity in certain parts of the set-up?"

Jack: "If you are referring to a pre-wired computer like Typhoon, that is a different thing altogether. But the complications of an automatic system to wire a computer for various subroutines would become fantastic."

Bob Howe (University of Michigan, Ann Arbor, Mich.) asked *Bernie Loveman* (Reeves Instrument Corp., New York, N. Y.) if he didn't have a subroutine setup on the new REAC—some sort of plug-in units.

Bernie answered that they have patchplugs which eliminate some patchcords by interconnecting amplifiers with resolver inputs. Amplifiers are arranged on the patchboard so that this can be accomplished. They use the same system with multipliers.

Ed Massell, referring back to Jack's question of when it is "wise" to use human labor, said that it isn't the labor that we are worried about. The cheapest way to make two electronic connections is to have a guy who doesn't know what he's doing put a patchcord between two holes. The problem is to be sure he gets them between the two correct holes. What we should try to do is to arrange the patching of an analog computer so it can be done by trained monkeys.

McLeod: "I believe that while we have been talking about saving human labor, everyone has had in the back of their minds the fact that it is the humans who make the mistakes. So if we can cut down on the human labor, a byproduct is cutting down on the chances of mistakes. That is what we are really interested in!"

Bob Howe, referring to Stan's multiple patchboard requirement, asked how you know, when you're setting up ahead of time, whether the guy over on the next station might be wanting that certain amplifier or not.

Otis Updike (University of Virginia, Charlottesville, Va.) suggested, "You plug in 'integrator' and the circuit will pick a free integrator."

Bob: "So, if they are all busy you get a busy signal!"

McLeod: "If a summer answers, hang up!!"

Howard Hamer (Electronic Associates, Long Branch, N. J.) wanted to know if San Diego was planning to borrow equipment from Pomona via long distance line.

McLeod said they haven't got to that yet, but he will work on it.

Lehmann asked about the Astronautics combined analog and digital simulation.

McLeod answered that they are preparing to use their extensive analog equipment with the IBM 704 for a rather complete weapon system simulation. There are several reasons for the combination. One is that they would probably need five 704's to do the problem in real time in the same detail if they didn't use the analog equipment. On the other hand, the digital equipment must be used because some parts of the simulation require great accuracy (e. g. the navigation problem). Equipment is divided up in general according to whether it is simulating analog or digital equipment in the real system.

Lehmann brought up the question of inaccuracies from the analog being fed to the digital computer for high-accuracy solutions.

McLeod said that is a standard question: "Why go to the digital computer with bum information? In this case you will usually find that they are using the digital computer to

close the feedback loop around the analog. In a servo system you can have a very low-performance actuator, but if you close a servo loop around it with tight-enough feedback, you can get good over-all performance."

Bob Howe pointed out that it is practical to use an analog computer to solve aerodynamic and kinematic equations of an aircraft and come out with angular rates, angle of sideslip, angle of attack, and missile velocity. Once you have these you can use your digital computer to compute the trajectory. If the analog computer makes a small error in computing the attitude angle, usually this simply acts like a small error in the trim of the aircraft, which gets taken out anyway in the closed-loop guidance system. You use the digital computer to perform long-time trajectory integrations where your analog computer falls down.

Jack Sherman spoke of Stan's desire to make component checks daily or oftener. "I think it is an excellent idea. Trouble is he talks about components. I think there should be some check on the passive elements—resistors, etc."

Massell said all this can be checked with a special patch panel setup. *Bernie Loveman* added that he believes this is described in Captain Johnson's new book *Analog Computer Techniques;* he sets up three sine waves in a REAC of 20 amplifiers so that he uses every passive component in making his check. If there is a small difference in them the sine wave in that circuit will differ from the rest.

Bob Howe agreed that it was a worthwhile check because of its simplicity.

The Patchboard Verifier

In answer to a question, *Loveman* described the Reeves patchboard verifier. You put the patchboard on a device which is practically a computer in itself. It starts at the upper left-hand corner and looks at the first hole. If there is a patchcord in it, it stops and scans to find the other end of the patchcord. It prints out first the connection where it started, and second the location of the other end of the patchcord. (It isn't fair to have a patchcord with more than two ends!—Ed.) The first connection is tabulated in black, the other end of the cord in red. When the verifier gets to the other end of a tabulated patchcord it goes on past so you don't have two readings on one cord. It takes a few minutes to scan a board of several thousand holes. The cost is about the same as a computer!

SIMULATION COUNCIL

Each connection is identified by means of a code number, and check sums are computed for each problem setup.

On a more general theme, *B. D. Bidne* (Westinghouse Air Arm, Baltimore) then pointed out that using every element of the computer in a single problem could detect only gross errors, since buildup of tolerances would preclude obtaining answers with errors less than several times the maximum individual component errors.

Ed Massell then commented that the new Convair special patch panel would check out each amplifier with its associated computing network separately, by applying balanced and inverted voltages to pairs of inputs. All the higher-gain inputs may be eliminated in groups, so that progressive output scans (with the automatic readout system) can be made at tighter accuracy tolerances. Similarly, multipliers and resolvers are checked individually in all quadrants.

Bob Howe described a poor man's method whereby you can pick up 98% of the errors by taking your road map—the computer diagram—and counting the number of inputs and outputs to and from each component. Checking this against your board only takes a few minutes. The difficulty is usually that you have patched in the wrong place; you catch this by finding, for instance, that you don't have enough outputs to amplifier number 15 and/or that you don't have enough inputs to amplifier 10.

Answering a question, Bob said a technique to take care of partial derivatives on analog computers is to take advantage of the fact that you have time available as a continuous variable, and you can integrate with respect to time. So when you solve the partial differential equation you preserve time as a continuous variable but approximate your derivative with respect to the spatial variables by finite differences. For example, if you are solving the partial differential equation which describes something like an aircraft wing taken as a beam, you split the beam into a number of discrete stations and write difference equations for the spatial derivatives. You end up with a system of simultaneous ordinary differential equations tied together with the proper cross-coupling terms. If the problem doesn't get too large this is a convenient way of attacking it.

Ed Massell said it occurred to him that the problem of presenting the solution of a partial might be nicely solved by the scope display described by *Sed Atwood.* The space variable is displayed along the x axis on the scope to give you a varying curve which can be photographed if you wish.

Bob Howe said that this has actually been done to look at the vibrations of a beam; you can see what appear to be snapshots of the beam at different times.

* * *

This meeting was followed by the annual highball party and there were two more "technical" sessions next day. But I will have to tell you about these some other time as this letter is getting too long, and there are other things which I want to cover this month.

SOUTHEASTERN S/C MEETING OF 5 DECEMBER ON "ERROR ANALYSIS"

Twenty-four representatives of nine organizations attended the Southeastern Simulation Council meeting at Georgia Institute of Technology in Atlanta on 5 December 1956.

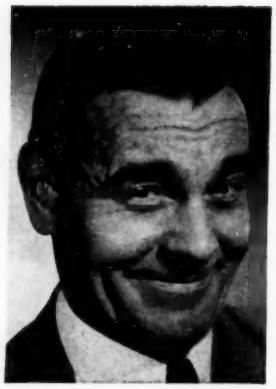
Bill Bradley (Murphy & Cota, Atlanta, Ga.) the outgoing Secretary, opened the meeting in the absence of the outgoing Chairman, W. K. McGregor (ARO, Inc., Tullahoma, Tenn.), and turned it over to the new officers, Chairman-elect M. David Prince (Georgia Tech) and Secretary-elect Edward G. Holmes (E. G. Holmes & Associates).

Richard Rimbach of Instruments Publishing Company was invited to describe the interest of the magazine *Instruments and Automation* in the Simulation Council's activities, and Fred Dixon (Georgia Tech) gave a report on the International Steering Committee meeting recently held in New York.*

After this Dave Prince turned the meeting over** to the Program Chairman, William Bennett (Lockheed Aircraft Corp.).

*Summarized under Info.

**If they turn this meeting over a few more times they should appoint "ole whirlin' John Brown" as Program Chairman! —Ed.



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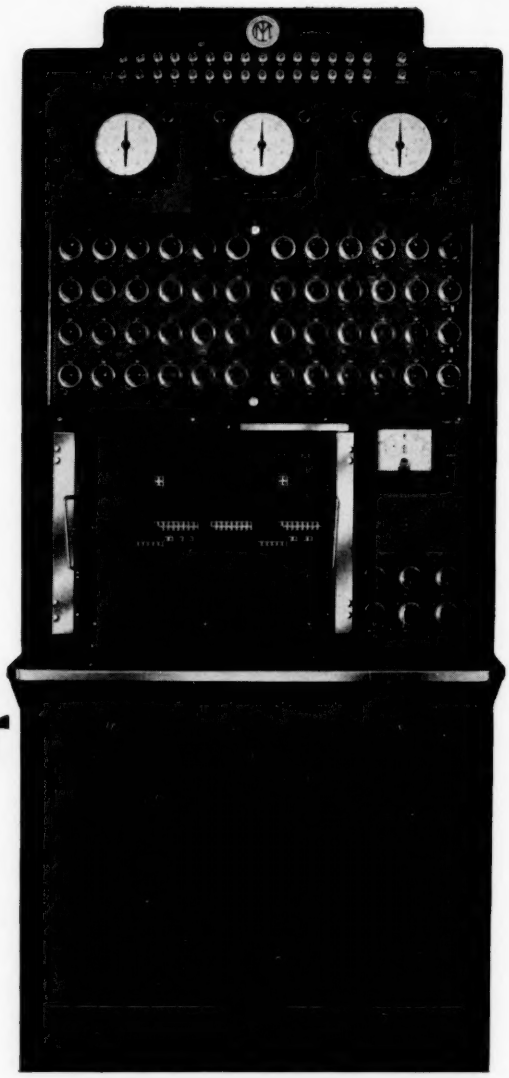
something!



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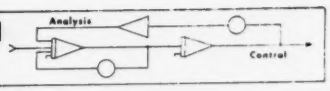

Johnson on Error Considerations in Analog Computers

The theme of the meeting was "Error Analysis." Bill introduced *Bob Johnson* (Georgia Tech), whose paper, "Basic Error Considerations in Analog Computers," classified errors arising from linear and nonlinear devices in analog computers. In his talk Bob brought out some interesting points:

The error introduced by a single resistor is due mainly to its noise, the ohmic variation from the nominal value, and the change in resistance with temperature. If we choose one resistor at random from a large lot, the ohmic error in this particular resistor will be constant, but the noise and temperature effect is time-dependent. The important point here is that the noise voltage is a high-frequency phenomenon with average value zero, whereas the temperature effect plus the ohmic variation is a low-frequency variation of average value not zero. Thus any integrating process will average out the noise, but will accentuate the static error.

The potentiometer contributes a slightly more complex error because of loading and inaccuracies in setting values.

Then there are the errors of summing amplifiers due to non-ideal gain, imperfect frequency response, phase-shift characteristics, and errors in the series and feedback resistors.

Integrators tend to accentuate systematic and static errors, but to decrease the error of time-variant functions such as noise. Because the error in the integrator output due to a static error in the input will be proportional to the length of integration time, it is possible to reduce this error by choosing a time scale which keeps the problem-run-time short.

Linear devices actually contribute only a minor part of the error in a computer solution. The greatest errors by far occur in the nonlinear devices such as multipliers.

The servo multiplier has a very limited frequency response, so where high precision is required the time scale must be selected to keep the frequencies low. Servo resolvers are subject to the same type of errors.

The electronic multiplier is capable of relatively high-frequency operation while maintaining resonable accuracy. The time-division type can easily achieve one-tenth percent accuracy with a frequency response flat to 200 cps.

Diode function generators exhibit little inherent error, particularly if silicon diodes or reduced-filament-voltage diodes are used. The precision of the function generation is limited by the break points available and the character of the function. These errors have been treated in a paper by *Howard Hamer* (Electronic Associates).

When using feedback techniques for implicit function generation the errors often add up in a peculiar manner. For example, if a one-tenth multiplier is used in a divider, then the percentage error due to the multiplier alone is equal to 10 divided by the denominator. When the denominator gets as small as one volt the error is 10 percent.

Error may be introduced also by an oscillating amplifier, rectified noise, or some other fault not easily detected. To make matters worse, these troubles often come up intermittently or only at one point in the course of a run. A technique found useful in several laboratories is to permanently wire an oscilloscope in parallel with the panel meter, so that any voltage being read on the meter is automatically displayed on the scope. Many times errors will thus be detected which would otherwise go unnoticed or be attributed to component tolerances.

Of course the best check on the over-all accuracy of a computer solution is an independent solution obtained by hand or a digital machine. This is often impractical and sometimes impossible, so we must usually depend on estimating the errors in the building blocks and extrapolate the results to the final solution.

At the conclusion of Bob's paper *Bill Bradley* commented that a considerable source of error not mentioned is the readout device.

Bill Bennett asked about the errors caused by noise and hum, to which Bob replied that they are usually kept below 15 mv, but if rectified they may cause appreciable error.

"What is the hum output of a function generator?" asked *Dave Prince*.

Bob replied that they have relatively high peak-to-peak hum output; one that he is familiar with has 0.5 volt.

"Does anyone here use any particular patchboard technique to avoid high-frequency oscillation?" Bob asked.

Sam Robinson (Lockheed Aircraft Corp.) replied that he always uses 50$\mu\mu$fd shunted across the output of the summing amplifiers.

Robinson on Differential Analyzers

Sam was the next speaker and presented a paper entitled "The Use of Differential Analyzers in Conjunction with the DC Analog Computer for Solving and Checking Differential Equations."

Sam reiterated that the best way to check solutions is to use another method. A Bendix Digital Differential Analyzer at the Georgia Division of Lockheed Aircraft Corporation (Marietta, Ga.) is used to check solutions obtained on analog computing machinery as well as on digital machinery. Bob then described the integrators and the fine points of the DDA.

Dave Prince asked whether it is possible to generate functions on the DDA, to which Sam replied: "You have several ways of doing this. The servo operations can be given the effect of diode limiting and cut in at various levels just like a diode function generator. It takes two integrators for each break-point, so a large number of integrators must be used. Another method is to plot your function as a silhouette on a graph and use a Photo-Electric Follower."

Bill Bradley asked if this reduces accuracy, to which Sam answered: "Yes, with this method you have analog accuracy." He then described a third method of generating functions using the tape-input machine, on which they feed the program into the machine. "After the information is in the machine we take off the tape and put our nonlinear function on it. Each time it comes to a break-point a new number is read off the tape which corresponds to the following slope. In this way you can use as many slopes as you wish."

Bill observed that this implied that you must have a tapereader.

Sam agreed, adding that it is part of the machine.

Bill: "This method only uses one integrator?"

Sam: "Yes, but only one function is generated."

Jimmy Petkas (Lockheed Aircraft Corp.): "I'd like to add that if you have several monotonic functions of time, you can put in as many as you want on the one tape, but if you have a reversible function then only one can be placed on the tape at one time."

Sam: "Right. If you want your forcing function to be repeated every

BERKELEY OPENS ITS NEW COMPUTER FACILITY

Beckman/Berkeley's new Los Angeles Computation Center, located at 305-307 Parkman Avenue, provides large scale computation service for West Coast industrial firms and research institutions. The location is easily accessible from all freeways.

Opening February 26, the center will feature Berkeley's all-new EASE* 1132 analog computer with its exclusive digital output-input translator system.

Consisting of two separate computers of 50 amplifiers each with associated non-linear equipment, this center represents an investment of $250,000 by Beckman/Berkeley. The two computers can be interconnected for solution of large problems.

Operating in conjunction with Berkeley's computer center in Richmond, California, the Los Angeles facility will be used for rental service to industry, for special demonstrations and for educational purposes.

The center's staff, directed by George A. Bekey, is available for consultation on engineering problems, assistance in problem preparation, and computer operation.

Inquiries regarding this center and the 1132 computer will be welcomed; please address Dep't. B-2.

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time you run the problem, this forcing function may appear in several places in different shapes, and you can put on as many as may be desired."

Bill asked: "Would you sum up as briefly as possible the advantages of the DDA over the DC Analog Computer?"

Sam: "The biggest advantage is the repeatability and the accuracy."

Bill: "Is it easier to set up a problem on the DDA?"

Sam: "It is almost identical to setting up one on the DC Analog Computer."

Bill: "Speaking in analog terms, what would you say the band-width of the DDA is?"

Sam: "It is infinite."

Bill: "I mean in real time."

Sam: "I said that it is infinite because a true step function may be introduced at any time, since the computer may be stopped and started at a different level. However, it takes about one minute to oscillate to one sine-wave while producing three-place accuracy."

This discussion was followed by a round-the-table discussion on computer facilities in the Southeast. Plans were made to tour the Computer Facility at Lockheed Aircraft Corporation the following morning, December 6th, and *Dave Prince* extended an invitation to all members to visit Georgia Institute of Technology Research Laboratory and Analog Computing Facility on Friday, December 7th.

INFORMATION (Without Theory)

All who are not interested in the modus operandi of the Simulation Councils can skip the next two paragraphs. However, some have indicated that a brief résumé of the decisions of the various Steering Committees is in order. So — —

At the New York meeting of the Steering Committee of the International Simulation Council it was decided that:

1. We would publish the *Simulation Council Newsletter in Instruments and Automation* for at least another year.
2. The Midwestern Simulation Council, which advocates private publication, would appoint a committee to study the matter.
3. We would investigate the practicality of holding our annual informal meeting in conjunction with the formal Joint Computer Conference (which already attempts to consolidate the computer interests of the IRE, AIEE, and ACM so that there are fewer rather than more national meetings in our field).
4. We would draft *Dr. R. M. Howe* of the University of Michigan to be Chairman of the Steering Committee, International Simulation Council, for 1957.

* * *

At the 10 January meeting of the Steering Committee of the Western Simulation Council it was decided that:

1. We should get on the ball with a more active permanent (one year!) Steering Committee, or the other Simulation Councils would leave the founding chapter in the lurch.
2. The present officers (*Jack Sherman*, Chairman; *Dov Abramis*, Vice Chairman; *Joe Hussey*, Secretary-Treasurer) should remain in office till July.
3. The Steering Committee should be composed of:

   Past Chairman (*Norm Irvine*)
   Present Chairman (*Jack Sherman*)
   Vice Chairman (*Dov Abramis*)
   Secretary-Treasurer (*Joe Hussey*)

and three members nominated and then elected by secret ballot of all present. This turned out to be:

John McLeod

Stan Rogers

Bill Kindle

* * *

In the May *Nucleonics* magazine there will be a special report on the use of analog and digital computers in nuclear design. Further info, Dan Cooper, *Nucleonics*, 330 West 42nd Street, New York 36, N. Y.

* * *

We received an announcement that our long-time friend *Lee Cahn*, formerly of Beckman Instruments, has formed the Cahn Instrument Company for the design, manufacture, and sale of scientific instruments in Downey, California (Office at 7712 Danvers Street, Laboratory and Plant at 11408 Brookshire Avenue). Good luck, Lee!

* * *

It is tentatively planned to hold the next DDA Council meeting at Ramo-Wooldridge Corporation, 8820 Bellanca Avenue, Los Angeles, the first week in April. The subject will be "Programming, Scaling, and Error Analysis for DDA." There will be a demonstration of the new "Litton 40" DDA. Further information from Stan Rogers, 3023 Alcott Street, San Diego. There is also a meeting planned for June or July, probably in the East.

Thot (or is it?)

Beware those that draw the line for they are Plotters!*

*Copyright available to digital vendors at a nominal fee.

Computer Events

Other events on page 224

Western Joint Computer Conference
Dates: 26-28 February 1957
Place: Hotel Statler, Los Angeles, California
Subject: "Techniques for Reliability"

Third Annual High-Speed Computer Conference
Dates: 5-8 March
Place: Louisiana State University, Baton Rouge, La.

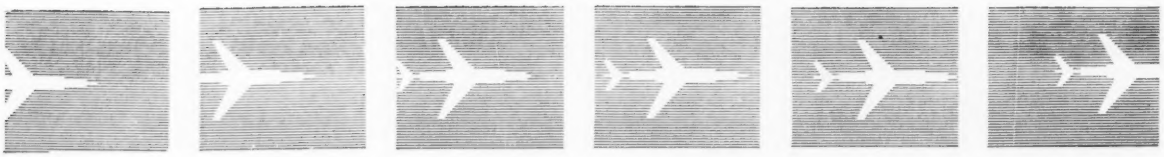
Western Simulation Council
Date: 14 March 1957
Place: Research Branch, Missile Systems Division, Lockheed Aircraft Corp., Palo Alto, Calif.
Subject: "Evaluation of Computer Usage"

Eastern Simuation Council
Date: 22 March
Subject: Simulation of Nuclear Reactors
Place: American Machine & Foundry Co., Fawcett Bldg., Greenwich, Conn.
Time: 10:00 A.M.
Host: Alfred Gronner, American Machine & Foundry Co.

National Simulation Conference on Computers—Southwest Regional Conference and Electrical Show, IRE
Dates: 11-13 April 1957
Place: Houston, Texas

Midwestern Simulation Council
Place: Houston, Texas
This meeting will be held in conjunction with the Southwestern IRE Conference and Exhibit at the Shamrock Hilton Hotel on 11-13 April.

ENGINEERS · SCIENTISTS



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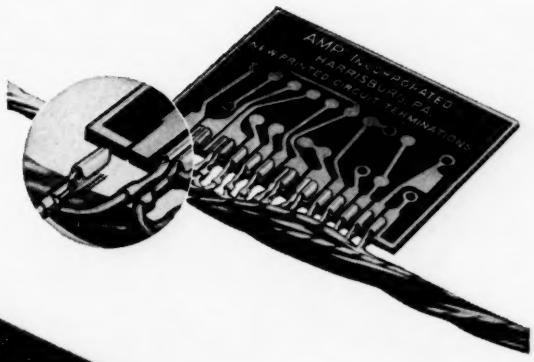

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INSTRUMENTS and AUTOMATION

New Instruments

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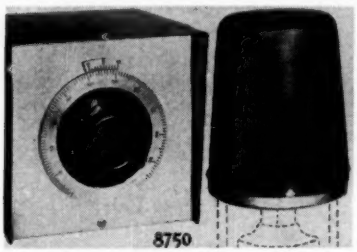
PROCESS MEASUREMENT and CONTROL

REMOTE POSITIONER

New "Dialtrol" is said to combine high accuracy and low cost. Vernier dial positions a variable-speed drive, a valve, rheostat, etc., through an actuator with built-in or externally-driven voltage-dividing resistor, using

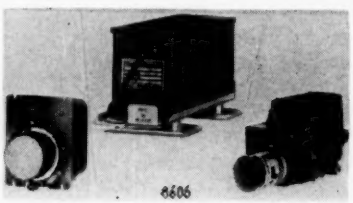


position-balance principle. Illustrated "Shaftrol" is designed expressly for use with "Dialtrol" but other gear-motors connected to suitable position-type voltage-dividing resistors can be used. Full-scale follow-up accuracy of 0.2% is standard; with precision multiturn resistors 0.04% and indication by counter rather than vernier. Standard feature: adjustable slowing down of servomotor as desired setting is approached. "Dialtrol" commands motors up to ⅛ hp directly and up to 50 hp through a reversing starter: can be located several thousand feet from actuator without loss of accuracy. Unlike synchro-type control systems, it can be set with power off: motor will move to desired position as soon as power is turned on. One "Dialtrol" can command several motors (with proportional control between them if desired). Standard systems operate on 115 vac. Explosion-proof enclosure available.—*The Jordan Co., Inc., 3235 W. Hampton Ave., Milwaukee 9, Wis.*

For more information circle **201** on inquiry card.

REMOTE POSITIONER

New remote positioning system, comprising transmitter, amplifier, and receiver, has been designed for maximum reliability; will either operate under any statistically reasonable failure, or will remain in position. It

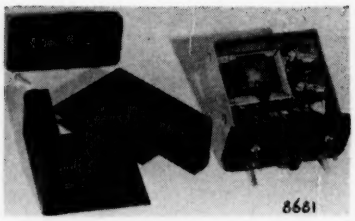


will never allow an undesired signal to move output shaft. Linear or rotary motion can be transmitted or received. Power supplies of amplifier and receiver need not be identical; amplifier requires 115 v, 400 cps, but receiver motor can operate on practically any available supply. Input-output ratio can be 1:1 or any other desired ratio. System accuracy is independent of load, since receiver motor gets full voltage for any error signal exceeding deadband, which can be as low as 0.2% of scale. Manual over-ride, inching control, and interlock features are available as options. —*The Bristol Company, Waterbury 20, Conn.*

For more information circle **202** on inquiry card.

CONTROL PACK

New miniaturized plug-in control pack contains all basic control circuitry needed for use with "meter-relays" (contact-type automatic-control millivoltmeters). It measures about 4"x2"x4": one-fourth the space usually required for such circuitry. Many circuit variations are available, but standard minimum parts include

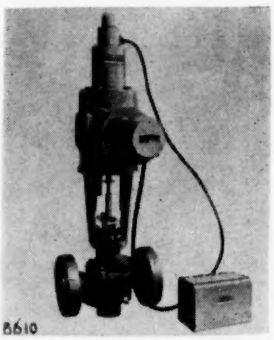


an isolation transformer, a dc power supply (including rectifiers), and slave relays to provide 5-amp 115-vac contacts. Frequently an interrupter or sampling circuit is also included. Standard 11-pin octal type base; four mounting studs; completely dust-tight case permits quick access to parts and wires.—*Tipp-Tronic, Inc., Tipp City, Ohio.*

For more information circle **203** on inquiry card.

ALL-ELECTRIC ACTUATOR

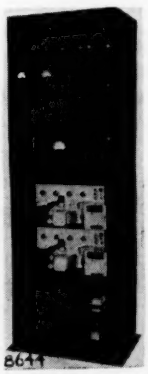
New "Series D" all-electric proportional positioning device, for use with modern electronic control systems,



requires no intermediate pneumatic or hydraulic operating fluids; is said to combine desirable features of an electric system with mechanical simplicity and ruggedness of maker's standard pneumatic actuators. Stroke length ¼" to 2"; stem speed 4 ipm at max rated output of 500-lb thrust. —*Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.*

For more information circle **204** on inquiry card.

SUPERVISORY SYSTEMS



New packaged protective and measuring systems for pipe lines, chemical industries, test facilities, etc., include plug-in electronic units for temperature, pressure and vibration protection; pressure measurement and telemetering. Plug-in unitized construction provides maximal compatability between system and installation. Only low-level sensing elements are located in hazard-

ous areas. Other features: double-pole contacts for alarm and shut-down functions; all-electronic circuitry; explosion-proof and fail-safe construction; ultraconservative ratings and premium vacuum tubes.—*Indikon Co., 76 Coolidge Hill Road, Watertown 72, Mass.*

For more information circle **205** on inquiry card.

COMBUSTION INSTRUMENTS

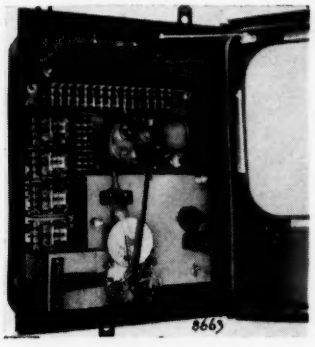
New line of combustion instruments provides automatic draft control to maximize efficiency of gas, oil or

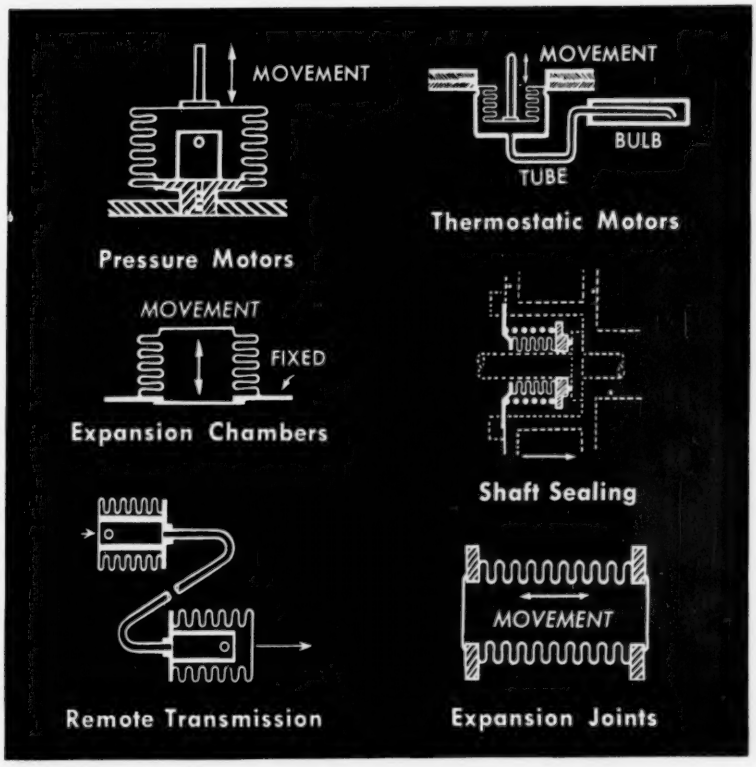
stoker-fired equipment; features new-type cast-aluminum cases which permit either flush or surface mounting as desired. "Draft Program Control," in conjunction with "Modulating Damper Actuator," maintains correct draft for all firing conditions. Companion instruments optionally available for close surveillance and accuracy are "Flue Gas Temperature Indicator," "Draft Gage," and "Steam Pressure Controller/Indicator" which controls fuel rate to burner in response to steam pressure changes.—*General Controls Co., 801 Allen Ave., Glendale 1, Calif.*

For more information circle **206** on inquiry card.

VISCOSITY RECORDERS AND CONTROLLERS

New "Model R3 Series Viscometer Recorders" comprises "Model R30" for recording only; "Models R31, R32 and R33" which contain one, two or three adjustable switch points respectively for on-off two-position and three-position control, also for alarms





ELIMINATE DESIGN "WEAK SPOTS" WITH Bridgeport SEAMLESS BELLOWS

The simple construction, straightforward operation, and light weight of Bridgeport seamless metal bellows make them the best answer for many temperature, pressure, and mechanical design problems. Hydraulically formed without soldered seams, they provide added strength and precision in shaft sealing, in obtaining controlled movement, in absorbing expansion or shock, in maintaining equal or differential pressures, and in transmitting motion remotely.

Bridgeport also offers two plus factors to make the most of any bellows application. Through integrated engineering of the bellows and all accessories, Bridgeport can supply complete bellows assemblies of many types, sizes, and metals. Ultra-modern production and quality control facilities assure increased uniformity and cost savings.

SEND FOR BELLOWS BULLETIN-CL

Mr. Controls®
Robertshaw-Fulton
CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION

MILFORD • CONNECTICUT

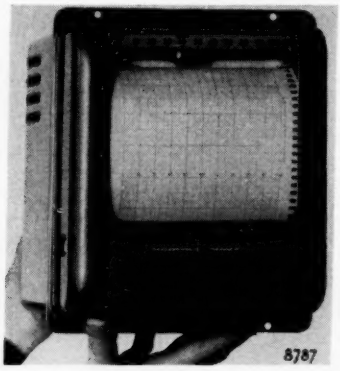
For more information circle **60** on inquiry card.

and signals; and "Model R3P" which provides a 3-15-lb output air pressure as a function of viscosity and hence can be used with pneumatic equipment to provide proportional control. —*Norcross Corp., Dept. #N27, Newton 58, Mass.*

For more information circle **207** on inquiry card.

STRIP-CHART RECORDER

New "G-11" self-balancing strip-chart recorder features full-scale balancing time of 1 sec; is suitable for

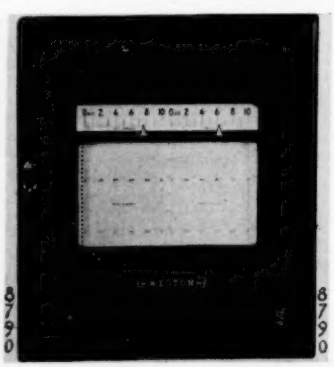


panel or relay-rack mounting or portable use. Measuring circuit is unitized. Various types of measuring circuit are under development; potentiometer model now available has behind-panel span adjustment to any value from 9 to 100 mv. Source resistances as high as 100,000 ohms are permissible. Rectilinear 5″ strip chart comes in 85-ft rolls. Single, dual and quadruple chart-speed models are available with speeds from ⅛″ per hour to 8″ per minute. Weight 15 lb.—*Varian Associates Instrument Div., 611 Hansen Way, Palo Alto, Calif.*

For more information circle **208** on inquiry card.

TWO-PEN 2-ZONE RECORDER

New "Model 6791" 2-pen 2-zone recorder, suitable for control room, production line or lab, is added to maker's "6700" line of unitized-construction recording-controlling instruments; comprises two independent instruments housed in a case 17¾″ wide to fit standard relay racks. It employs two electronic amplifiers of

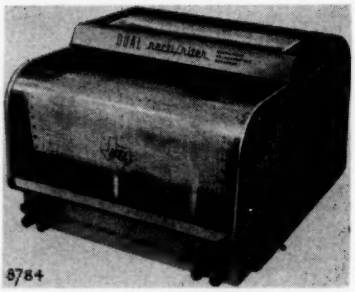


plug-in type for easy servicing, and two separate measuring circuits with replaceable range standards for quick range change. Alarm switches are available for each zone and can be set in seconds. Slidewires are interchangeable, and totally enclosed for complete protection. Chart speeds 1″ per hour to 1″ per minute. Choice of semi-automatic or fully automatic standardization on potentiometer.—*Weston Electrical Instruments Corp. (subs. of Daystrom, Inc.), 614 Frelinghuysen Ave., Newark 5, N. J.*

For more information circle **209** on inquiry card.

TWO-CHANNEL RECORDER

New "Dual recti/riter" rectilinear-writing galvanometric strip-chart recorder can record two functions simultaneously in their true wave-forms; is adaptable to a variety of circuits. Design features include "writing desk" area for manual notations on chart, front-located zero adjust, front-mounted controls and signal terminals, and finger-tip-shift 10-speed chart drive. Event marker pens can be mounted on each side of chart.



Closed inking systems with fine-line writing pens prevent evaporation and spillage and provide non-skip quick-drying inking over full 4½″ deflection. Full-scale rise-time, 0.25 sec, is said to be "fastest of any recorder in its class." Choice of ac, dc, spring, or external drives with 100-ft charts. Movements available in 1, 5, 10 or 25 ma input for full-scale deflection. Dc accuracy 1% of full-scale.—*Texas Instruments Inc., Industrial Instrumentation Div., P. O. Box 6027, Houston, Texas.*

For more information circle **210** on inquiry card.

TEMPERATURE

DIFFERENTIAL THERMOMETER

New "Model B Fiske Precision Differential Thermistor Thermometer," said to be "easier to use and less

expensive than thermocouple or thermopile equipment," can be used for actual temperatures or temperature differences. Previous models have been used to measure phenomena to a repeatability of 0.001 C° for several years "without aging, drift or hysterisis." Features: high recorder-controller voltage output, no reference junctions, no electronics, remote operation, sensitivity 0.0005 C°.—*Advanced Instruments, Inc., 18 Oakcrest Road, Needham 92, Mass.*

For more information circle **211** on inquiry card.

RESISTANCE THERMOMETRIC PRIMARY ELEMENTS

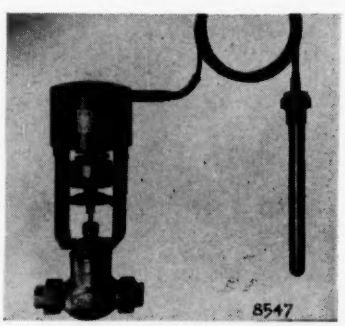
New "Type 1300 Stainless Steel Bulb Temperature Pick-Ups" are resistance elements with outputs up to 5 v. Temperature interval over which 100-ohm resistance change will occur

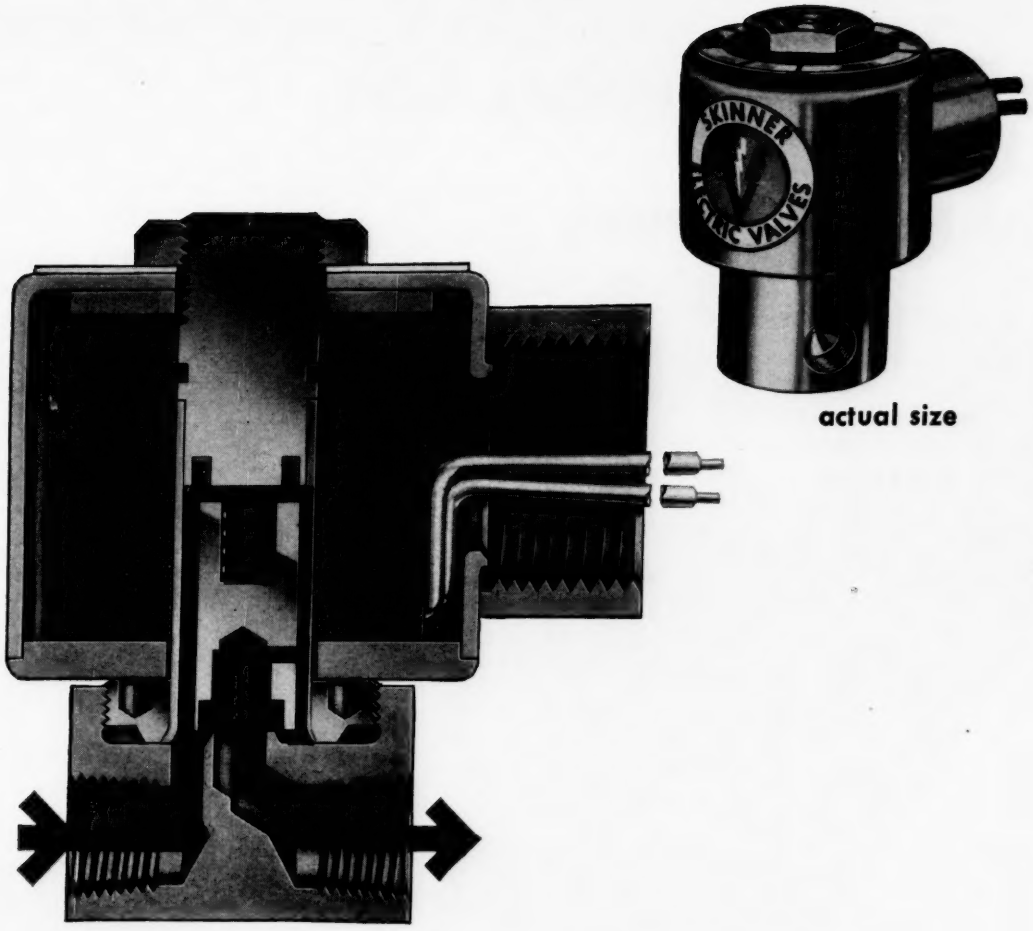
can be as short as 100 F°. Accuracy is unimpaired by 25 *G* to 2000 cps vibration. Limits of available ranges are −300°F and 1800°F. Bulbs can be furnished for installation in corrosive fluids. Accuracy 1% of full-scale range; precision 0.2% of full-scale range; maximum continuous current 20 ma rms (averaged over 1 second); thermometric lag less than 2.5 sec in agitated water.—*Trans-Sonics, Inc., Box 328, Lexington 73, Mass.*

For more information circle **212** on inquiry card.

TEMPERATURE CONTROLLER

New safety-type "No. 997 Temperature Regulator" closes automatically if thermostatic unit should be acci-





actual size

New C-series solenoid valve offers recognized "Skinner Quality" at low cost

This is a faithful reproduction—in miniature—of the time-tested, 2-way, normally closed Skinner V5 except that the body is made of brass.

This new, compact Skinner valve weighs only 12 ounces, yet it's rugged enough to last millions of cycles on most applications.

This new valve has orifices from 5/32" to 7/64", with pressures ranging from 60 to 130 psi. Pipe size is 1/8" NPT. It is a packless, direct-acting valve with only two moving parts. And it's absolutely bubbletight—even on vacuum. This C-Series Skinner valve is fail-proof, too—a built-in spring return assures positive closing; thus it can be mounted in any position and is ideal for direct-line mounting.

You'll find this new valve, with its recognized "Skinner Quality," the perfect low-cost answer to a wide range of flow control problems. It works efficiently with air, water, oils, gasoline and many other media. Typical applications include: automotive fuel systems, welding equipment, vending machines, lubricating devices, spraying equipment, air horns, water softeners, humidifiers and instrumentation.

Our Bulletin D11.1 contains complete information on this valve—flow curves, optional features, dimensions, electrical data, etc. We will be happy to send you a copy on request.

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
THE SKINNER CHUCK COMPANY

For more information circle **62** on inquiry card.

SIE **MODEL E-2**

COMPARISON BRIDGE

FOR FAST, ACCURATE MATCHING OF

RESISTORS *1 ohm to 5 megohms*
CAPACITORS *500 mmfd to 2000 mfd*
INDUCTORS *3 millihenrys to 10,000 henrys*

- Five Meter Ranges: 1%, 2.5%, 5%, 10% and 25% difference readings at full scale
- Accurate within 0.1% on 1% scale
- Component differences of 1 part in 10,000 can be detected
- Foot operated switch available

$185.

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Industrial Instruments Division

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220-55

For more information circle **63** on inquiry card.

NEW INSTRUMENTS

dentally damaged. Its special tight-closing single-seated valve makes it suitable for "dead end" service. Sizes from ¼" to 2".—*Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Box 400, Knoxville, Tenn.*

For more information circle **213** on inquiry card.

TEMPERATURE CONTROLLER

New "Type F56 Remote Bulb Temperature Control" is a wide-range uncalibrated skeleton unit designed for use in ovens, incubators, etc., where space or weight is a limiting factor. Basic components: control head with attached bellows, bulb, and capillary tube that connects bulb to bellows. Models of "Type F56" are available with a span of 200 F° between limits of −150°F and 150°F or 70°F and 370°F; or with a span of 500 F° between limits of 100°F and 650°F. On-off differential is about 1 F° or 2 F°. Choice of switches: normally-open, normally-closed, or double-throw with no neutral position.—*United Electric Controls Co., 85 School St., Watertown, Mass.*

For more information circle **214** on inquiry card.

THERMOSTAT

New "C7216 Klixon" snap-acting disc-type thermostat, for applications where maximum shock and vibration

resistance are required, features "Spencer Disc" thermal element, hermetically sealed assembly, copper-nickel plated steel casing specially plated for corrosion resistance. Standard temperature settings (fixed) from −20°F to 400°F.—*Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.*

For more information circle **215** on inquiry card.

SHOCK-PROOF THERMOSTAT

New "Klixon C6786" snap-acting disc-type thermostat, designed for applications where high shock and vibration resistance is required, has snap-acting-disc and fine silver contacts enclosed with a stainless steel cup; base assembly available in phenolic or silicone construction. Operating temperatures from −20°F to 400°F; factory-preset. Terminals are solder type. Rating 2 amp resistive 115 vac, or 5 amp resistive 30 vac/vdc. Weight 2.5 grams.—*Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.*

For more information circle **216** on inquiry card.

MINIATURE THERMOSTAT

New "Tini-Tempswitch," said to be "particularly useful for a precision temperature control in cathode tubes and in many other applications," is available in plain, flanged or screwed head mounting, in two-wire or grounded type. Rated load 1 amp 110 vac. Various ranges available; unit will operate repeatedly on extremely close differential of ⅛° in a properly-designed and heat-balanced system—*Scaico Controls Inc., Palmyra, N. J.*

For more information circle **217** on inquiry card.

THERMOCOUPLE TESTER

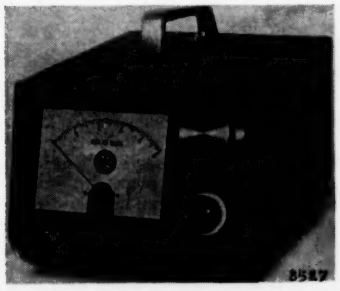
New "Model 387" millivoltmeter, for checking voltage output of safety thermocouples on gas-fired equipment, is simple to use. Clips are merely placed across TC terminals to test for correct voltage. Ranges are 10, 30, 100, 300, and 1000 mv. Accuracy is 3% of full scale at ambient temperatures of 50° to 120°F. From −55° to 185°F, an additional error of no more than 2% can be expected.—*Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.*

For more information circle **218** on inquiry card.

HUMIDITY

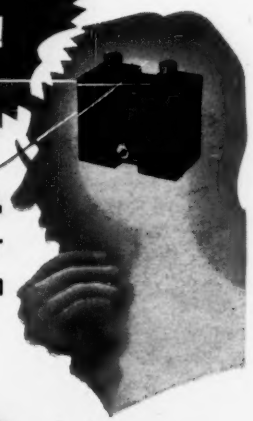
HUMIDITY MONITOR

New "Type 26-301 Moisture Monitor," for accurately measuring minute quantities of moisture in gaseous

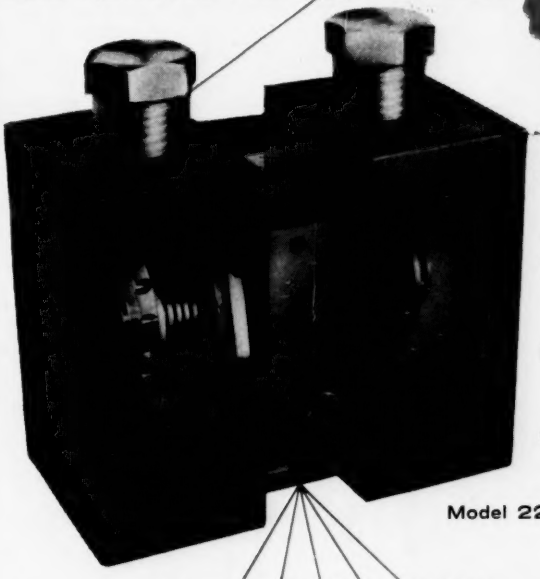


mixtures, is suitable for research, quality control, and process efficiency. It will measure water content accurately down to 1 ppm, and permit precise readings over full-scale range of 0 to 1000 ppm by means of a 5-step attentuator. Its output can be telemetered. Principle (developed by duPont): an electrolysis cell in instrument continuously absorbs and electrolyzes all water present in a sample stream. A direct voltage is applied to cell elements and electrolysis cur-

THINK MODERN!



insist on **BARTON 224**
DIFFERENTIAL PRESSURE UNIT
when specifying your instrumentation



small
3" x 4" x 3"

light
under 8 lbs.

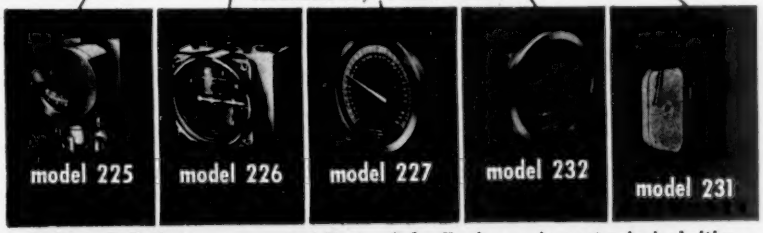
rugged
portable, versatile

accurate
stable, reliable

Model 224

The Model 224 like the well known Model 199 incorporates the patented Barton Rupture Proof Bellows principle and can withstand over-ranges up to the pressure rating of the housing regardless of the differential pressure range of the unit. This unit obsoletes the lubricated pressure tight bearing, by transmitting bellows motion to the exterior of the housing through a torque tube. With differential pressure ranges from 0-75" W.C. to 0-400 psi and housings rated from 500 psi to 3000 psi, the Model 224 offers a maximum of flexibility and utility.

Available in five basic models.

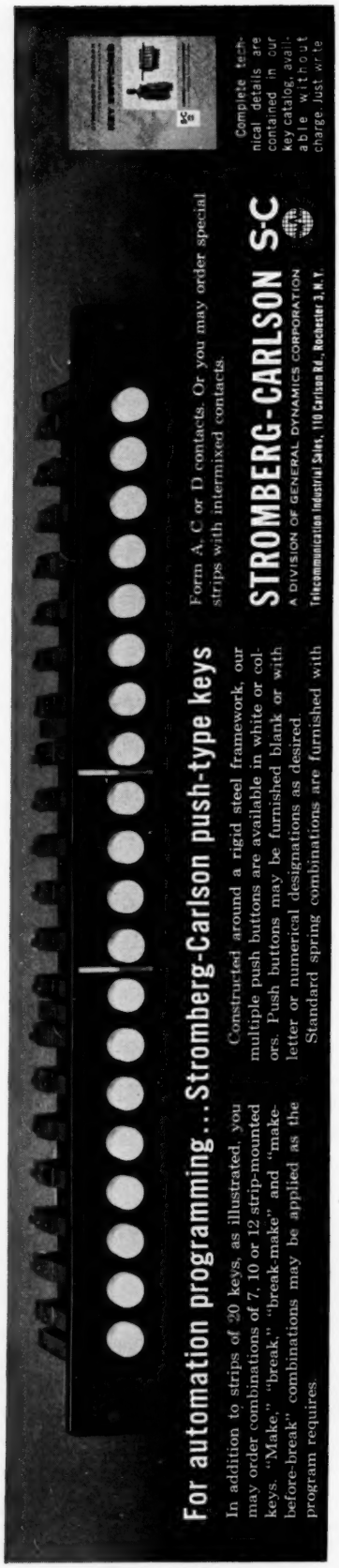


Refer to Bulletin 224-1 or contact Barton Sales Engineers in most principal cities.

BARTON INSTRUMENT CORPORATION

580 MONTEREY PASS ROAD, MONTEREY PARK, CALIFORNIA

For more information circle **64** on inquiry card.


For automation programming...Stromberg-Carlson push-type keys
In addition to strips of 20 keys, as illustrated, you may order combinations of 7, 10 or 12 strip-mounted keys. "Make," "break," "break-make" and "make-before-break" combinations may be applied as the program requires.
Constructed around a rigid steel framework, our multiple push buttons are available in white or colors. Push buttons may be furnished blank or with letter or numerical designations as desired.
Standard spring combinations are furnished with Form A, C or D contacts. Or you may order special strips with intermixed contacts.
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Telecommunication Industrial Sales, 110 Carlson Rd., Rochester 3, N.Y.
Complete technical details are contained in our key catalog, available without charge. Just write
For more information circle **65** on inquiry card.

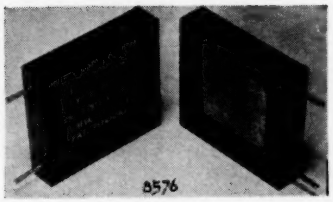
NEW INSTRUMENTS

rent (related directly by Faraday's Law to mass flow-rate of water into instrument) is a measure of water content. A flow controller keeps flow-rate constant. Among operating advantages: electrolytic cell is easily removed through an opening in front panel; an adjustment method is provided for remote recorder calibration.—*Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif.*

For more information circle **219** on inquiry card.

HYGROMETRIC ELEMENTS

New "Hygropak" resistance-type humidity-responsive elements utilize thin films of new materials developed for this purpose. Among advantages: (1) High speed of response;



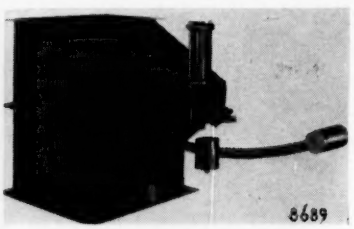
(2) various types of coatings available for measuring either high or low relative humidities; (3) availability of positive- or negative-resistance types of coatings; (4) plastic-case elements operate up to 200°F and glass units to 600°F; (5) user can select commercial dc or ac bridge circuit components and instruments for portable or control-board hygrometric systems.—*Photo-Crystals Inc., 15 South First St., Geneva, Illinois.*

For more information circle **220** on inquiry card.

FLOW-RATE

SELF-OPERATING FEEDER

New "Series A-619" self-powered feeder used to control the feed of dry free-flowing materials at rates from

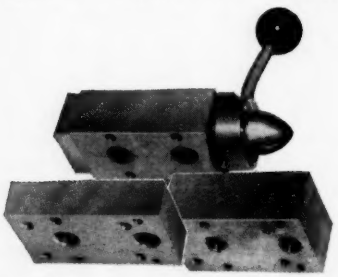


200 to 2000 lb/min operates on the principle of balanced weights. Force produced by material being fed, as it falls onto an impact pan, is balanced by a preset counterweight. Units are available with automatic shut-off to permit starting or stopping of feeder, or synchronization with other plant equipment.—*Wallace & Tiernan Inc., Belleville 9, N. J.*

For more information circle **221** on inquiry card.

ADJUSTABLE FLOW REGULATOR

New "Model 1400, adjustable flow regulator adapted for manifold

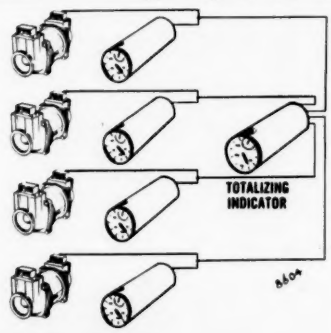


mounting comes with subplate kits with built-in check valves for free reverse flow; is easily installed; weighs 5 lb; has all exterior aluminum surfaces anodized.—*Waterman Engineering Co., 725 Custer Ave., Evanston, Illinois.*

For more information circle **222** on inquiry card.

MASS FUEL FLOWMETER

New gravimetric fuel flowmeter whose accuracy is unaffected by variations in density, temperature, vis-

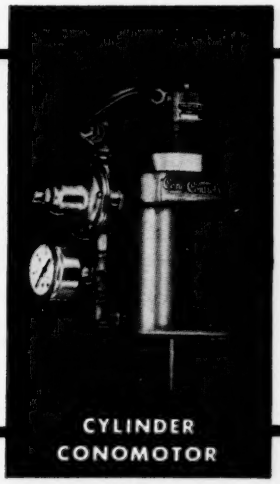


cosity or chemical composition of fuel, provides true mass flow-rate indications without use of auxiliary density-correcting devices. Principle: A constant-speed impeller imparts a momentum to the passing fuel proportional to mass flow-rate. This momentum is transmitted to a spring-restrained sensing wheel, whose deflection (proportional to mass flow-rate) is converted to a direct voltage. This dc signal is modulated to produce an indication, in pounds per hour, at cockpit panel. Hydraulic design of transmitter, plus self-balancing indicating system, provides linear indication over entire flow range and a vernier subdial permits precise interpolation. Response time of indicating system is less than 5 seconds for full-scale pointer travel. Indicators' integral lighting meets both "aviation red" chromacity requirements of AN-C-56,

CONOFLOW *Shows You the Way to* AUTOMATION

HERE'S HOW

YOUR PROCESSING EQUIPMENT + INSTRUMENT +

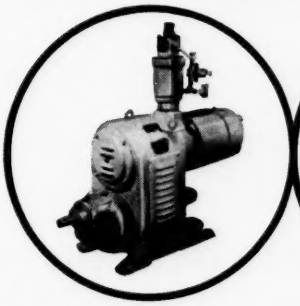


= COST-CUTTING AUTOMATION

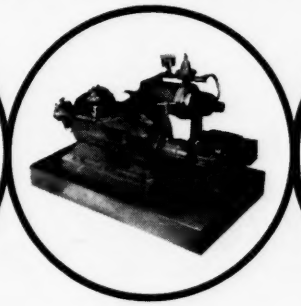
The Conoflow Cylinder Conomotor—a powerful pneumatic actuator—has accelerated industry's approach to the automatic factory and the continuous process plant. A wide range of final control elements, never before available, has been created by the Cylinder Conomotor, a servo capable of following the exact signal outputs of modern electronic and pneumatic instruments.

Cylinder Conomoters, acclaimed by industry as the ultimate in control valve actuators, are fast becoming the standard for automatic control of other process regulating equipment. A few of these are: motor driven speed changers, proportioning pumps, flow regulators, electric timing devices, and numerous electrical systems components such as rheostats, autotransformers and potentiometers.

A FEW EXAMPLES OF CONOFLOW AUTOMATION . . .

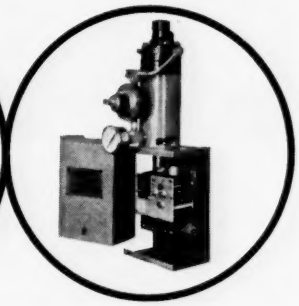


U.S. Electrical Motors
Variable Speed Drive



Proportioneers
Proportioning Pump

Kates
Flow Regulator



Dorr-Oliver
Electric Timer

Conoflow application engineers, well versed in systems engineering methods, will gladly help you evaluate the use of the Cylinder Conomotor on your equipment. Avail yourself of the tremendous advantages offered by this concept of automation, including increased productivity . . . savings in man power . . . improved quality control . . . and many other benefits. Call or write today for "personalized" service. Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa. Representatives in principal cities.

WRITE FOR BULLETINS B-50-2-A AND EB-2-A

CC-700

Conoflow Controls®

CONOFLOW CORPORATION

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Subsidiary of Walworth

For more information circle 66 on inquiry card.

THE MARK OF QUALITY

BARBER COLMAN

Wheelco Instruments

How Capacitrols solved critical temperature control problem in transistor manufacture at RCA

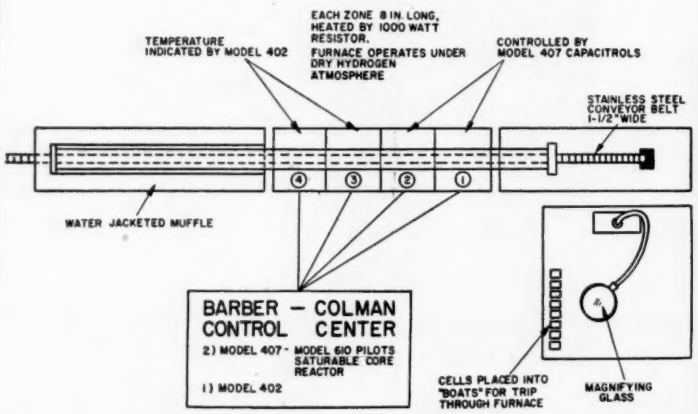
EACH ZONE 8 IN. LONG, HEATED BY 1000 WATT RESISTOR. FURNACE OPERATES UNDER DRY HYDROGEN ATMOSPHERE
TEMPERATURE INDICATED BY MODEL 402
CONTROLLED BY MODEL 407 CAPACITROLS
STAINLESS STEEL CONVEYOR BELT 1-1/2" WIDE
4
3
2
1
WATER JACKETED MUFFLE
BARBER – COLMAN CONTROL CENTER
2) MODEL 407 - MODEL 610 PILOTS SATURABLE CORE REACTOR
1) MODEL 402
CELLS PLACED INTO "BOATS" FOR TRIP THROUGH FURNACE
MAGNIFYING GLASS

Diagram above shows smaller of two furnaces producing transistor cells. Two minute balls of indium are alloyed onto opposite sides of a .002 in. thick slice of germanium. Zones of germanium-indium alloy must grow inward toward central plane of germanium wafer to within .001 in. of each other. Conveyor belt carries cells through four furnace zones heated by resistors rated at 1000 watts per zone. Two Model 407 Capacitrols control temperature of zones 1 and 2. One Model 402 Capacitrol indicates temperatures in zones 3 and 4 by switching.

Photo at left shows workers preparing cells before Wheelco Control Center of larger, 12-zone furnace on which Model 407 Capacitrols similarly control and indicate temperature. Controlled temperatures are 610 to 550 C.

By applying accurate Wheelco 400 Series Capacitrols to two furnaces, RCA solved the key problem of process temperature control during crystal growth in its Harrison, New Jersey, transistor plant. The 400 Series Capacitrols are completely self-contained, direct-deflection-type indicating controllers with a wide range of application to jobs where temperature control is critical. 400 Series Capacitrols operate on the proved and accepted Wheelco "electronic control principle"—a precise control circuit constantly sensing changes in the measured variable. Simple design, careful workmanship, and quality materials insure long, trouble-free service. Write today for details of RCA's challenging problem and the simple solution found in Wheelco's 400 Series Capacitrols.

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Industrial Instruments • Automatic Controls • Air Distribution Products
Aircraft Controls • Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

For more information circle **67** on inquiry card.

NEW INSTRUMENTS

and intensity specification of WADC Ex WCLEI-3-10. Performance of system meets all temperature, vibration and other environmental requirements of MIL-E-5272A. Present production models are designed for flow rates up to 45,000 pph but system can accommodate flow rates as high as 600,000 pph. System is factory-calibrated and requires no field adjustments. Its components are interchangeable.—*Avien, Inc.*, 58-15 *Northern Blvd., Woodside* 77, *N. Y.*

For more information circle **223** on inquiry card.

LIQUID LEVEL

LIQUID LEVEL CONTROLLER

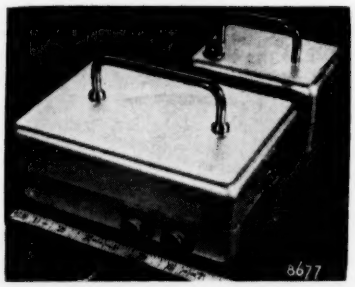
New "Dynatrol" features fail-safe operation; utilizes a unique "motor-generator" combining (1) a vibrator

driven by line frequency and (2) a tiny pickup whose output ceases at high level. For low-level detection, generator output energizes relay when level drops. Absence of electronic tubes assures reliability. No float, no packing, no close tolerances. Standard model is accurate to 0.01"; explosion-proof; 115 vac, sp-dt; 1000 psi pressure rating at 150°F.—*Automation Products, Inc.*, 3030 *Max Roy St., Houston* 24, *Texas.*

For more information circle **224** on inquiry card.

LIQUID-LEVEL DETECTOR

New liquid-level detector features completely-transistorized high-reliability construction and 0.02" detection accuracy. Single and multichannel units are available. Current through



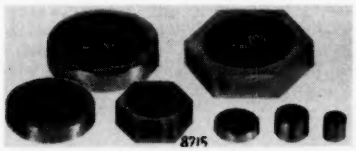
liquid is only a few microamps. Explosion-proof, portable, and conduit-box packaging are standard. Operation is from 28 vdc, 117 vac or self-contained batteries; signal output by relay operation. A ten-channel detector is pictured.—*Southern Engineering, 309 Volunteer Bldg., Chattanooga, Tenn.*

For more information circle **225** on inquiry card.

PRESSURE, VACUUM, LOAD, FORCE, etc.

PRESSURE & LOAD PICKUPS

New "Celab Pressure Cells" feature absence of moving parts, can be used to measure (1) fluid pressures, (2) weights or loads, (3) forces, vibrations, etc. They utilize "Celab Plastic,"

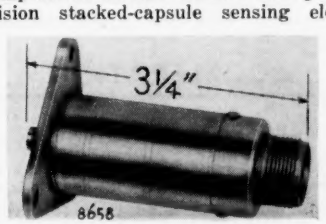


a hard elastic material whose electrical resistivity changes when it is compressed. (Actual compression said to be "not measurable.") Cells can be produced with almost any desired final resistance, depending on heat treatment during manufacture. Some can be used for measuring local pressures in the human heart, others for explosion studies. Low-pressure models are claimed to be "the most sensitive made, having a top sensitivity of 10,000 ohms change with a differential of 0.002 mm Hg in a cell ¼" by ¼" weighing 2 grams." Low pressure units must of course be used at known temperatures and, for high-precision work with most models, temperature corrections should be applied (curves on request). All cells are undamaged by temperatures from −50°F to +425°F. Cells require no amplifier, most being capable of several watts output. Illustration shows some models available for immediate shipment. They are sensitive on one side only; 2-, 3- or 4-side units to order; also models with two or more sensitive areas on one side.—*Clark Electronic Labs, Box 165, Palm Springs, Calif.*

For more information circle **226** on inquiry card.

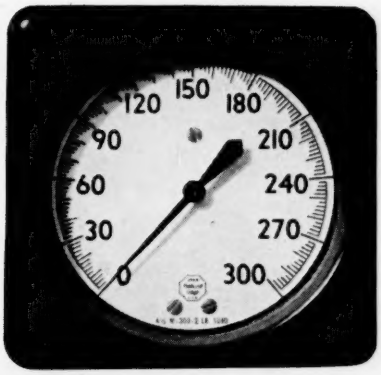
HI-TEMP PRESSURE SWITCH

New "Type 6576 High Temperature Pressure Switch" can operate at 650°F by use of all-welded stainless steel construction, advanced type of snap-action switch element and precision stacked-capsule sensing ele-



Helicoid Gages

Long-life gages to meet every pressure indicating requirement



Acaloy square case for flush mounting

Acaloy flanged case

For pressure, vacuum or compound service

Ranges from 15 to 20,000 p.s.i.

Tubes of bronze, alloy steel, stainless steel and K Monel for all types of gas or liquid.

Cases are flanged, flangless, flush mounted, square or circular and with white or black dials.

Chemical gages with diaphragms to seal off objectional substances from indicating gage.

Chemical gage with black dial

Only HELICOID has the HELICOID movement

All HELICOID Gages provide the sustained accuracy that only the famous HELICOID—no gears—movement provides.

Write today for the **HELICOID G-2 CATALOG**

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929-B Connecticut Avenue • Bridgeport 2, Connecticut

For more information circle **68** on inquiry card.

PALMER
MERCURY ACTUATED

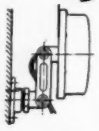
DIAL THERMOMETERS

in 3 types to suit any requirements

Full 4½" dial face. Stem can be placed at any angle and case can be rotated to any readable position.

1 **Rigid Stem Dial Thermometer** tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)

2 **Wall Mounted Dial Thermometer** with flexible connecting armor. Case adjustable to easy reading position.



3 **Flush Mounted Dial Thermometer** for panel mounting with flexible connecting armor.

All three types have a full 4½" dial face.

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensaton. Guaranteed Accurate 1 scale division.

for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.

Write for Catalog Information

PALMER
THERMOMETERS, INC.
Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory Recording and Dial Thermometers

For more information circle **69** on inquiry card.

NEW INSTRUMENTS

ment. Contacts are sp-st or sp-dt, 1 amp inductive, 28 volts. Absolute-pressure version provides an adjustment range of 20 to 75 psia. Gage-pressure style available. Proof pressure 100 psi; burst pressure 150 psi. —*Manning, Maxwell & Moore, Stratford, Conn.*

For more information circle **227** on inquiry card.

MULTISTATION VACUUM GAGE

New "Type 2203-03" one- to four-station Pirani vacuum gage gives direct continuous readings of total pressure of condensable vapors and permanent gases on two scales: 1-50 microns Hg and 50-2000 microns Hg; features a new sensing tube which greatly reduces zero drift (serious problem in previous hot-wire gages). This tube operates at the exceptionally low maximum temperature of 250°C and carbon deposits on filament do not change its emissivity. Both sensing and compensating tubes are enclosed in a single metal envelope to minimize ambient-temperature effects. Automatic voltage regulation facilitates operation and permits use of a 0-10-mv recorder without constant operator attention.—*Consolidated Electrodynamics Corp., Rochester Div.*, 1775 *Mt. Read Blvd., Rochester* 3, *N. Y.*

For more information circle **228** on inquiry card.

PRESSURE REGULATORS

New "Series 20AG and 20AG-X" regulators provide precise control over their full operating range regardless of wide flunctuations in main line air pressure and widely-varying air flow; also greater air capacity than previous models; also lower prices on some sizes. New regulators are also designed for use with water, oil and non-corrosive gases; are available in pipe sizes from ¼" through 1"; are offered in relieving and non-relieving type.—*C. A. Norgren Co.*, 3400 *S. Elati St., Englewood, Colorado.*

For more information circle **229** on inquiry card.

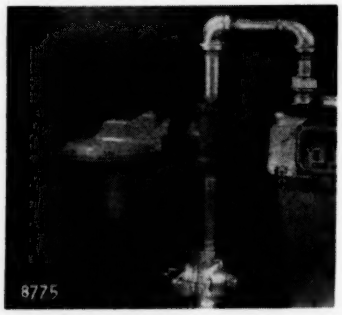
PRESSURE REDUCER

New pneumatic pressure reducer, designed to conform to MIL-R-8572A, weighs from 0.4 lb to 0.6 lb (depending on model) and is available in ¼" and ⅜" tube sizes (larger models special). Built-in relief valve is standard but reducer can be supplied without. Unit reduces pressure from 3000 psi, is completely balanced producing straight-line regulation, features leak-tight shut-off and small initial pressure drop under flow conditions. Operating temperature range −65°F to 225°F for pneumatics (higher temperatures possible with slight modification of internal design).—*Pneu-Hydro Valve Corp.*, 364 *Glenwood Ave., East Orange, N. J.*

For more information circle **230** on inquiry card.

SERVICE REGULATOR

New "143" light-weight internal-relief service regulator has "almost double the relief capacity of any previous service regulator": about 3000 ft^3/hr with outlet pressures of 1 psig or less, owing to three major new design features: (1) direct upward venting through spring housing when internal relief valve is open, (2) spring housing design providing largest vent area in any service regulator, (3) large passages allowing pressure build-up to be quickly transmitted to lower diaphragm case and, once internal relief valve has opened, permitting large flow from main gas line to lower case and vent line. Other new features include 360° swivel, large pliable diaphragm and new boosting principle.—*Meter & Valve Div., Rockwell Mfg. Co.*, 400 *N. Lexington Ave., Pittsburgh* 8, *Pa.*



For more information circle **231** on inquiry card.

ACCELERATION

ACCELERATION PICKUP

New "Series LA03-0200" utilizes a high-output voltage-dividing resistor and a pressure-sealed case (already

ANNOUNCING THE 104 MEMO-SCOPE

The MEMO-SCOPE Model 104 is a new memory oscilloscope with a selection of 5 plug-in preamplifiers that will satisfy the most critical production, test and laboratory requirements. MEMO-SCOPE incorporates the famous Hughes-developed Memotron direct-display storage tube that captures and retains any number of traces indefinitely at a constant intensity until intentionally erased. Traces are readily visible in a brightly-lighted room, and may be easily photographed for file records.

MEMO-SCOPE 104 SPECIFICATIONS

ERASURE: internal waveform generator triggered by front panel push button or by external switch.

DC BLANKING: CRT grid direct coupled to external or internal blanking gate allows beam to be turned off except during sweep and insures constant sweep-time intensity over any sweep duration.

DEFLECTION PLATES: available at rear terminal strip for direct connection.

MAIN VERTICAL DEFLECTION AMPLIFIER: frequency response of DC to 700 kilocycles within 3db. Rise Time of 1/2 microsecond.

TRIGGERED LINEAR SWEEP: range of 10 μsec to 10 seconds per division, adjustable continuously or in 18 calibrated steps. Trigger: vertical amplifier signal, AC line or external pulse, either polarity, DC or AC coupled. Minimum external trigger amplitude: 0.1 volt. Neon ready lamp indicates sweep is at left side of screen, ready for trigger.

AMPLITUDE CALIBRATOR: available at front panel terminal—one kilocycle square wave with peak-to-peak amplitude of 0.01, 0.1, 1.0 or 10 volts, within 3%.

BEAM POSITION INDICATORS are four neon lamps showing position of writing beam when not on screen.

ILLUMINATED GRATICULE: scale calibrated in 1/3" squares in 10 X 10 array.

RACK MOUNTING: Model 104 available on standard 14" X 19" relay rack panel.

DIMENSIONS: 13" wide, 14" high, 20" deep. Etched circuit epon-glass electrical chassis. Hinged camera mount optional.

OPTIONAL PLUG-IN PREAMPLIFIERS INCREASE FLEXIBILITY

(All units with frequency response from DC to 250 kilocycles down 3db.)

WB/4. Wide Band, DC.

WB/SE/5. Wide Band, DC plus Speed Enhancement.

HS/6. High Sensitivity—1mv/division differential.

HS/SE/7. High Writing Speed, High Sensitivity.

HS/D1/10. High Sensitivity, Dual Input.

For additional information or demonstration of the new Model 104 write to HUGHES PRODUCTS
MEMO-SCOPE
International Airport Station
Los Angeles 45, California

HUGHES PRODUCTS

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For more information circle **70** on inquiry card.

to meet your specialized needs . . .

A COMPLETE LINE OF

Arnold O. Beckman INC.

OXYGEN ANALYZERS!

For time-saving, *accurate* measurements of Oxygen in your process or laboratory operations, select from the complete range of Oxygen Analyzers offered by Arnold O. Beckman, Inc.

Each instrument operates on the field-proven Arnold O. Beckman *paramagnetic* principle which makes a direct physical measurement on the Oxygen itself. No chemicals, no complicated secondary relationships are used!

MODEL D2—Spot-checks on purged tanks, lines, or flue gas are done quickly and conveniently with the Model D2. This unit is completely self-contained, battery-operated and weighs only 3½ lbs. Operation is simple—merely squeeze a bulb to draw sample into the Analyzer, press a switch, and observe the O_2 concentration indicated on the graduated scale. Available with either 0-25% O_2 (0-190 mm) or a 0-100% O_2 (0-760 mm) dual range, the Model D2 accurately performs to ±2% of full scale.

MODEL C—For higher accuracy with narrower ranges (than available with the D2), the Model C will meet your more advanced needs. Select almost any single range 0-5%, 0-10%, 16-21% 85-100% O_2 etc. (or equivalent in mm O_2 partial pressure). Accuracy is ± 1% of full scale. A 95% response to any reading is obtained in less than one minute. Oxygen content is read directly from a graduated scale. Measurements may be taken on either continuous or fixed volume samples. 115 Volts 50/60 cycles. Weight: 12 lbs.

RECORDING ANALYZERS—For continuous, automatic operation, Models F3 and G2 Analyzers provide millivolt, current, or pneumatic output for operation with standard recorders. Ranges from 0-0.1% O_2 to 0-100% O_2, 16-21%, etc. Multiple ranges, explosion-resistant cases, as well as complete sampling systems are available extras with the Models F3 or G2.

MODEL E2—The precision-designed Model E2 fits the needs of installations requiring maximum accuracy. Offering a choice of single or multiple ranges, the Model E2 provides quick, easy readings when a potentiometer dial is manually adjusted to restore a light beam to its null position. Oxygen content is read directly from the dial. Minimum range 0-1% O_2 with accuracy of ± 1% of full scale. Ranges 0-5% O_2 and wider . . . accuracy ± 0.5% of full scale. 115 volts 50/60 cycles. Weight: 31 lbs.

FOR MORE INFORMATION—Outline your particular problems and let Arnold O. Beckman's experienced engineers offer recommendations for your specialized needs. Bulletins on any and all of the Arnold O. Beckman Analyzers are yours for the asking.

For General Information, Ask for Data File 21G-27

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Profit Builders for Industry
1020 MISSION STREET
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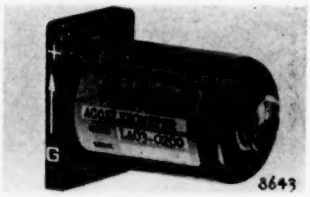
For more information circle **71** on inquiry card.

NEW INSTRUMENTS

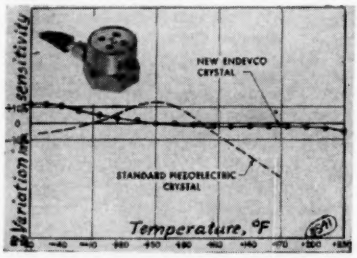


in use on target drones and missile systems); is available with connector or with solder terminals; features operating temperature range from −50°C to 100°C; typical ranges from ±5 *G* to ±35 *G*; resolution to 0.3%. —*Humphrey Inc.*, 2805 *Canon St., San Diego* 6, *Calif.*

For more information circle **232** on inquiry card.

ACCELERATION PICKUPS

New line of force, acceleration and pressure pickups features a recent advance in piezoelectric materials:

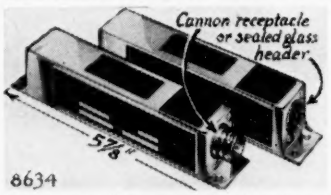


less than 10% change of sensitivity over temperature range of −65°F to 230°F, obtained without sacrificing additional features of high sensitivity (10 mv/*G*), high natural frequency (35 kc), high *G* range (10,000 *G*) or thimble size.—*Endevco Corp.*, 161 *E. California St., Pasadena, Calif.*

For more information circle **233** on inquiry card.

BIPLANAR ACCELERATION PICKUP

New "Model GDM" is a light-weight (14 oz) variable-resistor-type pickup which measures lateral accelerations



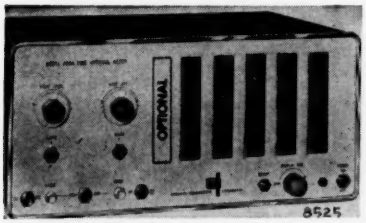
in two mutually-perpendicular planes; is said to be ideally suited for aircraft and missile instrumentation requirements. Operating temperature range −10°F to 180°F. Balanced range units are available in ranges from ±2 *G* to ±30 *G*. Unbalanced range instruments can also be supplied. Frequency response closely approximates a second-order first-degree system.—*Genisco, Inc.*, 2233 *Federal Ave., Los Angeles* 64, *Calif.*

For more information circle **234** on inquiry card.

TIME

10-USEC TO 1-SEC TIMER

New "Model 250A Time Interval Meter," for precise measurement of intervals in range of 10 usec to 1 sec

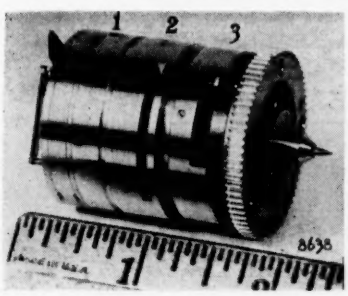


(option extension to 10 or 100,000 sec). Accuracy is 10 usec; measurement interval can be started and stopped by independent or common voltages representing optical, mechanical or electrical events. Among features: two independent continuously-adjustable trigger level controls permitting full rated sensitivity (0.07 v rms) at any voltage level between −50 and +50 v. Small increments of voltage, ordinarily masked by attenuators, are easily selected even though high voltage bias levels, voltage steps, square waves, etc., are present. Provision for 'scope marker signals for trigger level adjustment of start and stop points for measurement of complex waveforms.—*Computer-Measurements Corp., 5528 Vineland Ave., North Hollywood, Calif.*

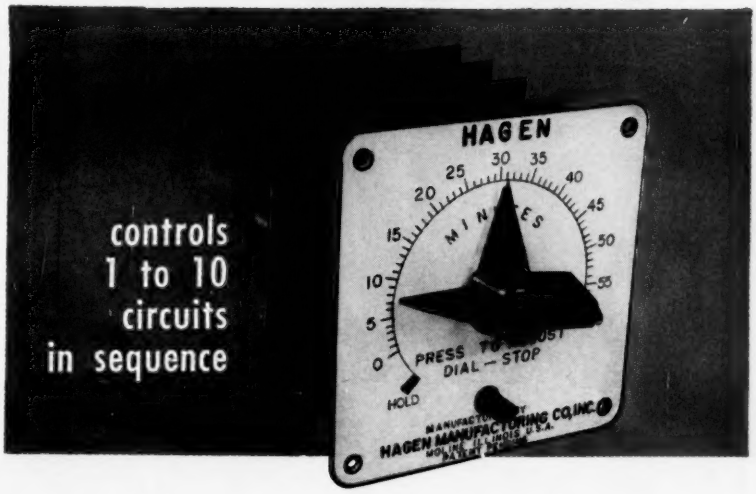
For more information circle **235** on inquiry card.

TIMING MECHANISM

New timing mechanism of extraordinary ruggedness and versatility is composed of interchangeable 1¼"-dia cartridge-like modules of three functional types: (1) "watch" or time-interval measuring unit, (2) spring drive unit, and (3) control mechanism actuated by time measuring unit for opening and closing electric circuits. Each type of module is available in several standard forms, to provide different torques, different lengths of total time cycle and different sequences; so that many different combinations can be obtained from a small number of standard building-blocks. Operating temperature range −65°F to 165°F; impact resistance 3000 *G* applied up to 0.01 sec; small reduction in accuracy when



NEW HAGEN
hand set
time delay relay



Foolproof on Repeat Settings

No danger of over-timing when you repeat a process several times — each with the same timing. On the first run, operator simply presses the stop release button and sets the adjustable stop (both shown in blue) at the desired time . . . then turns the pointer as far to the right as it will go . . . it can't go beyond the stop. Thus the setting is always correct — on the first and all subsequent runs.

A synchronous motor returns the cam shaft to "O" position, tripping switches in accordance with time settings. The process is stopped automatically.

A wide selection of snap-action switches is available . . . as well as cam combinations. The Hagen Hand Set Time Delay Relay Model 73 is the answer to controlling solenoid valves in an industrial process, starting a group of motors in sequence, for pump controls, and many other uses.

Send for Bulletin 580

MAIL COUPON TODAY!

HAGEN MANUFACTURING COMPANY, INC.
Dept. IA-257, Moline, Illinois

Please send Bulletin 580 on the new Hagen Hand Set Time Delay Relay.

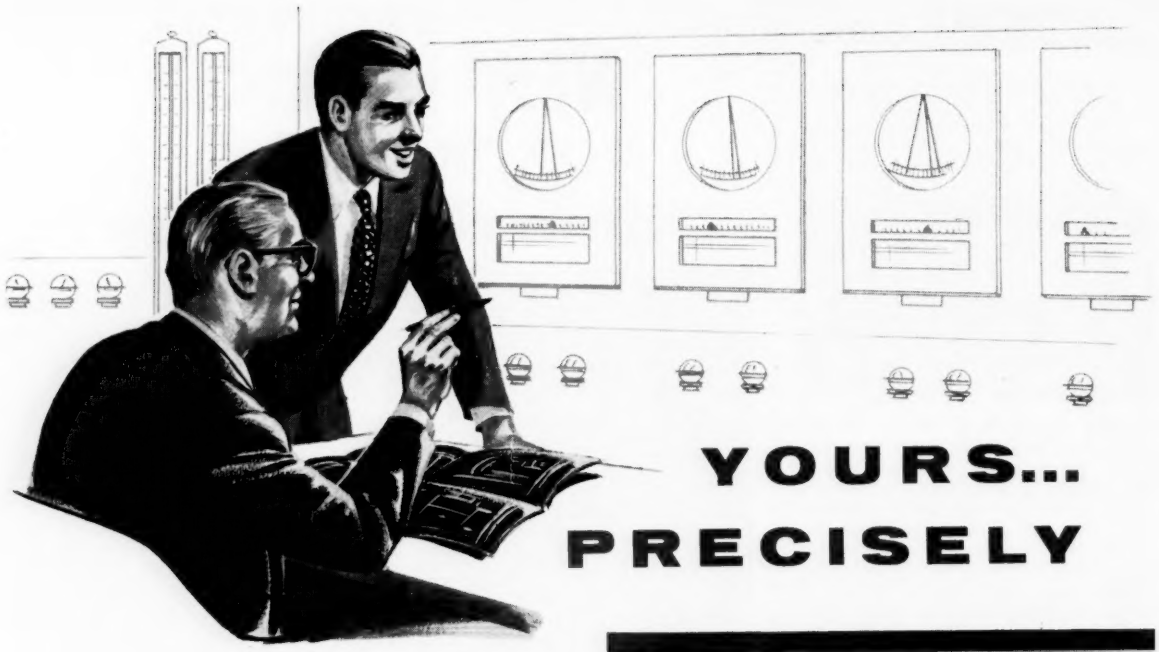
NAME AND TITLE

COMPANY

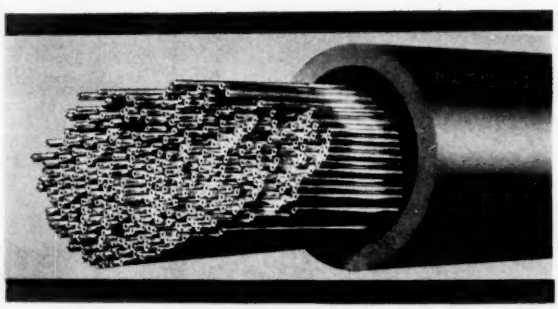
ADDRESS

CITY ZONE STATE

For more information circle **72** on inquiry card.



YOURS... PRECISELY



Meeting the demands of modern instrument and automation control is a job for tubing produced the Wolverine Tubemanship* way.

The precision metering of liquids and gases is made to order for tiny, plug-drawn Wolverine Capilator®. Because it is plug drawn (it's actually formed over a tiny mandrel made from piano wire) Capilator's inside diameter is mirror-smooth—can be held to the close flow tolerances asked for by the customer.

For control tube applications, manufacturers can specify Wolverine small diameter tubing in a wide range of sizes, wall thicknesses and alloys in copper, brass and aluminum.

Also of major importance are Wolverine's complete fabrication facilities. One-piece, tubular shapes with fully or partially closed end treatments can be produced in one economical operation by Wolverine's unique Spun End Process †. Other fabrication techniques include bending, coiling, flaring, expanding, etc.

To be sure of tubing that meets your exact specifications make Wolverine Tubemanship your "buy" word. For complete information write for your copy of the Wolverine General Products Catalog.

*Tubemanship is Wolverine's word for tube manufacturing based on years of metalworking experience, constant research, sound engineering and rigid quality control—make it your watchword!

†A PATENTED PROCESS RE 22465

National Electrical Week
February 10-16, 1957

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CALUMET DIVISION
WOLVERINE TUBE DIVISION
FOREST INDUSTRIES DIVISION
GOODMAN LUMBER COMPANY
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PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

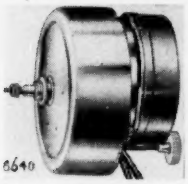
EXPORT DEPT. 13 E. 40TH ST., NEW YORK 16, NEW YORK

For more information circle **73** on inquiry card.

rotated on own axis at high speed. With appropriately-designed cases and attendant mechanisms, fail-safe operation and underwater operation are practicable.—*Hamilton Watch Co., Allied Products Div., Lancaster, Penna.*

For more information circle **236** on inquiry card.

ELECTRIC CLOCK MOVEMENT

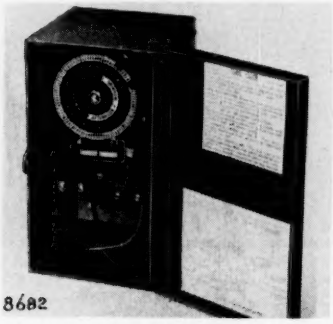

8640

New "1805" 2½" dia full-enclosed unit with synchronous electric motor drive is said to be one of the smallest and lightest completely enclosed movements available. It has hour, minute and second hand arbors and is complete with back setting knob; can be supplied for either 115- or 230-v 60-cps operation.—*Haydon Mfg. Co., Inc., 245 East Elm Street, Torrington, Conn.*

For more information circle **237** on inquiry card.

THREE-POLE TIME SWITCH

Newly redesigned and improved "Model 1963" 3-pole time switch, for controlling three-phase power and


8682

lighting loads, offers a choice of four dial styles: regular 24-hour dial, skip-a-day dial (for eliminating week-end operation), astronomic dial (for lighting to conform with sun's schedule), and 7-day dial (to program an entire week's varied schedule on the one dial) in enclosures best suited for particular installation. It is the first time switch that can be used to control a 1½ hp 3-phase motor directly. —*Tork Clock Co., Inc., Mt. Vernon, N. Y.*

For more information circle **238** on inquiry card.

ADJUSTABLE DELAY RELAYS

New "TD404" surface-mounting "TD405" flush mounting type dial-adjustable timers are especially useful where frequent change in time setting is necessary. Clutch holding contacts can be supplied as a special feature. Reverse clutch action can be incorporated so that clutch is normally locked in: unit then will be in timed

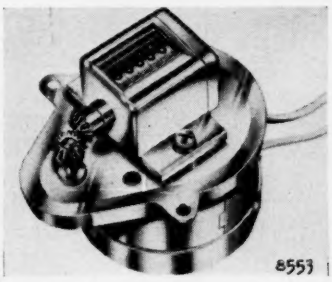
8641

out position normally and will reset to starting point when clutch is momentarily energized. With clutch coil wired through an external switch, unit will time out and maintain position without power consumption. Wide choice of time delay and operating voltage ranges.—*The A. W. Haydon Company, Waterbury, Conn.*

For more information circle **239** on inquiry card.

ELAPSED TIME INDICATORS

New "7500 Series" dc units employ standard or chronometrically-governed DC motors; "12500 Series" ac

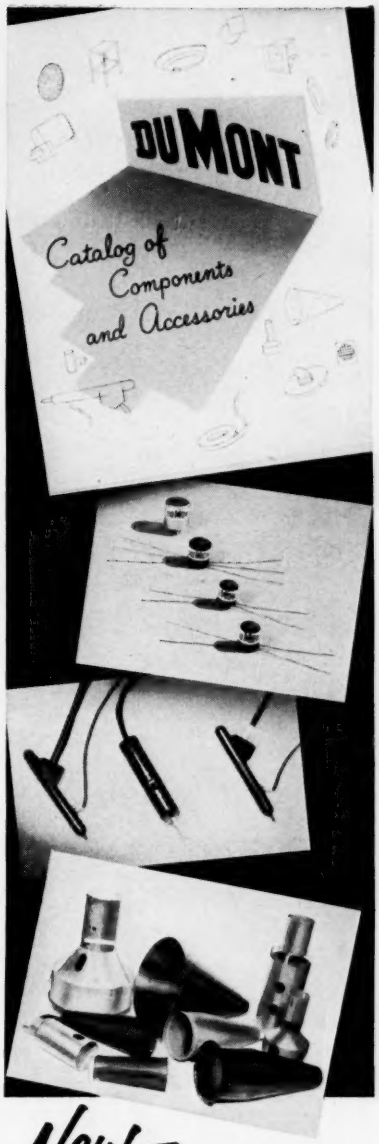

8553

units employ synchronous 50- or 60-cps motors; "24200 Series" use synchronous 400-cps motors. Wide variety of range or motor types; reset type units and hermetically-sealed housings also available.—*The A. W. Haydon Co., Waterbury, Conn.*

For more information circle **240** on inquiry card.

DELAY NETWORKS

New "Type 801" continuously variable delay networks, with incremental time delay less than 0.08 millimicrosecond and total time delay up to 1000 usec, feature absolute stability, no time jitter, hence are suitable for precision triggering systems, computers, etc. A unit of these delay networks consists of three step-variable delay lines and a continuously-variable delay line connected in tandem. Each step-variable delay line consists of 110 sections of *LC m*-derived networks and a 20-pole 10-position rotary switch. Each section of these networks is especially designed to give minimum rise time and essentially zero overshoot. Rotary switch serves to alter number of *LC m*-derived sections connected in tandem, in order that a desirable amount of time delay can be secured between the input and output connectors. Four models: 55.55, 111.1, 555.5 and 1111



New— and Complete

Illustrated listings of components and accessories for oscilloscopes including specifications on such items as knobs, pulse transformers, probes, magnetic shields, photographic recording equipment, racks and carrying tables. Many more miscellaneous items listed in easy to read form.

• ***Write for your copy***

DUMONT

ALLEN B. DU MONT LABORATORIES, INC.

Technical Sales Dept. • Clifton, N. J.

For more information circle **74** on inquiry card.

Only the men are flying

The fact is, men beat birds at their own game. Even when our feathered friends are grounded, we're aloft; flying ever higher, faster, safer, further. And, unbelievable as it may seem, more accurately.

Among the companies spearheading man's conquest of the sky are nine of the GPE Group. Their contributions are basic—technological bench marks such as—

- the only compass systems that *always* know where north is, whatever the plane does, wherever it goes: Kearfott's stable-platform gyro compasses;
- the only simulators to meet the need for on-the-ground training in supersonic flight: famous Link jet simulators;
- the only airborne navigation systems in operational use guiding planes automatically and with unprecedented accuracy — anywhere, in any weather: GPL Doppler autonavigators.

Inertial navigation, missile guidance, photoscience, and certain nuclear power applications, are some other phases of aviation in which GPE companies are deeply and jointly involved. And while many of the products of the GPE companies — particularly in the field of aviation—serve defense needs today, the important scientific advances they embody are "plowshares" for tomorrow.

Aviation is but one industry in which GPE companies work. A brochure describing the activities of the group is available. More than a dozen basic industries are served by products resulting from GPE coordinated technologies and resources.

GENERAL PRECISION EQUIPMENT CORPORATION

PRINCIPAL PRODUCING COMPANIES • Askania Regulator • GPL • Graflex
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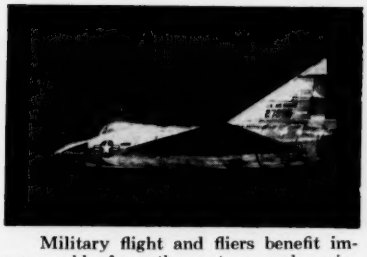
For more information circle **75** on inquiry card.

man aloft

The pilot – before he set eyes on this jet, before he set hand to the actual controls – had already "flown" it. He learned how, on the ground, in a Link F-102 Simulator . . . one of more than a million fliers who have logged "Link time." Millions more will.



Military flight and fliers benefit immeasurably from the systems and equipments developed by GPL, Kearfott, Librascope and the other GPE companies working in aviation. Once these classified products are released for civilian use, everyone will enjoy their benefits.

The coordinated resources of the companies of the GPE Group, so effective in anticipating and meeting the needs of flight, serve with equal effectiveness other industries such as:

Automatic Controls and Instrumentation
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For brochure describing the work of the GPE Group, write to: GENERAL PRECISION EQUIPMENT CORPORATION, 92 Gold Street, New York 38, New York.

For more information circle **75** on inquiry card.

NEW INSTRUMENTS

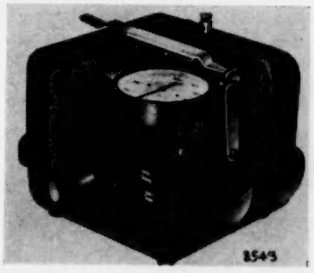
usec delays. After calibration, accuracy can be maintained within 0.1% by use of correction curves. Front panel is 5¼"x19" with standard rack mount slots.—*Advance Electronics Lab., Inc., 451 Highland Ave., Passaic, N. J.*

For more information circle **241** on inquiry card.

SPEED

HAND STROBOSCOPE

New "Deuta Combination Stroboscope reads directly from 400 to 500,000 rpm in two speed ranges; can be

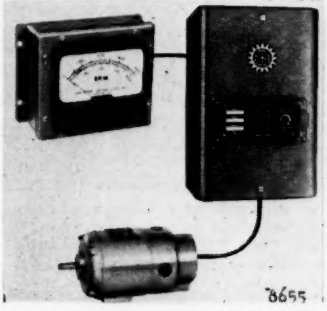


hand-held, supported on a special chest support, or tripod-mounted. A reflector for bright illumination is supplied.—*EPIC, Inc., 154 Nassau St., New York 38, N. Y.*

For more information circle **242** on inquiry card.

TACHOMETRIC CONTROL

New "MEK-2060 Speed Sensor Relay" allows processing or testing cycles to be automatically started or



stopped after a preset speed has been reached; can be used also as an underspeed or overspeed limit; to automatically synchronize two processes or machines, etc.—*Machinery Electrification, Inc., Northboro, Mass.*

For more information circle **243** on inquiry card.

SPEED-CONTROL PICKUP

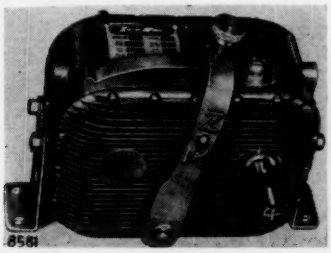
New "Model 3040 Power Pickup" self-generating power source for operating directly over- and under-speed

controls or warning devices is similar in operation to maker's voltage-producing "Magnetic Pickups," but provides sufficient power to operate low-voltage electrical devices without an amplifier. Power output is about ten times that of "Model 3010-A," with an optimum load of 1000 ohms and 750 mh average pickup inductance. At actuating surface speeds of 250 ips or more, it can operate relays having 100 mw sensitivity. When using two germanium diodes in a voltage-doubler circuit, it will operate a conventional 2500-ohm vacuum-tube plate circuit relay.—*Electro Products Labs., 4501 Ravenswood Ave., Chicago 40, Ill.*

For more information circle **244** on inquiry card.

VARIABLE-SPEED DRIVE

New "Model 24 Zero-Max" infinitely-variable speed reducer features a new lever control giving faster speed



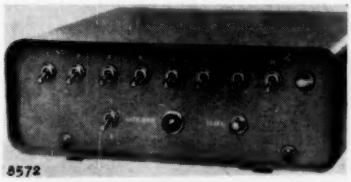
changes and simpler remote-control setups. Output speed setting can be changed instantly while unit is operating or stopped. Output shaft can be stopped without stopping power source. Large quadrant can easily be calibrated. Speeds are claimed to be repeated accurately.—*Revco, Inc., 1900 Lyndale Avenue South, Minneapolis, Minn.*

For more information circle **245** on inquiry card.

COUNTING

PRESET DIGITAL COUNTER

New transistorized digital counter, in association with appropriate pickups, counts articles, distance, degrees

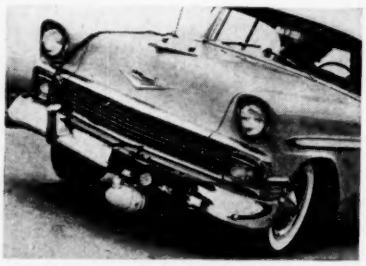


of rotation, or angular measurements —at speeds to 15,000 counts per second (higher speeds special). Extremely dependable operation is achieved by using transistors instead of vacuum tubes. Small size and moderate cost are obtained by employing printed circuit boards and modular construction. Total power consumption (2 watts) is no more than filament

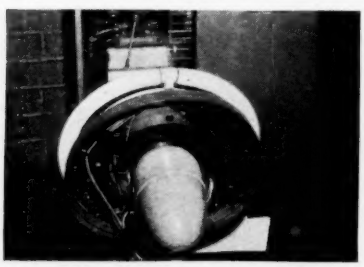
CLOSED-CIRCUIT TV
in action

See how industry is solving tough problems *visually*—with GPL *ii-TV

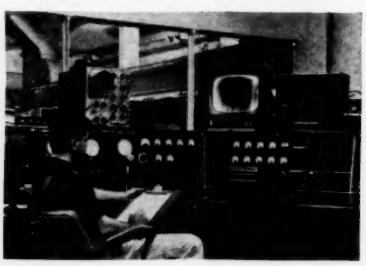
Quick record reference via *ii-TV* permits concentration of records in one area, saves this user $30,000 a year. GPL system is simple enough for anyone to operate.



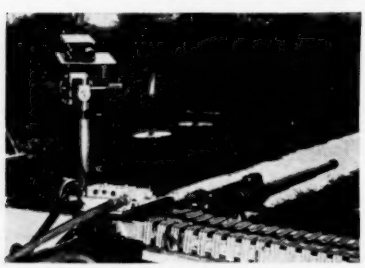
Hard-to-see actions, as in the bouncing under-chassis of GM cars in road test, *above*, can now be viewed. Standard GPL TV camera takes hard knocks in stride.



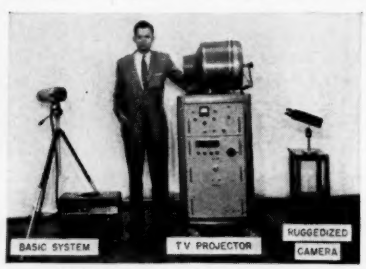
Monitoring distant meter saves this manufacturer substantial sums in electric bills by avoiding peak loads. Reliable, remotely located TV camera by GPL needs no tending.



Observer is safe when dangerous operations, like this one involving radiation at Brookhaven National Laboratory, are seen through sharp pictures of GPL camera.



Even bone-shattering concussions can't disturb perfect pictures of GPL's Ruggedized camera, designed specifically for most severe applications.



Basic *ii-TV* system is finest, most dependable; costs less than medium-priced car. Mobile GPL TV Projector gives wall-size pictures 300% brighter than any other.

SEE *ii-TV FOR YOURSELF**

For further details, or demonstration of this precision-engineered system in your own office or plant by local GPL representative, write on your letterhead to Mr. N. M. Marshall, Sales Manager, General Precision Laboratory Incorporated, 61 Bedford Road, Pleasantville, N. Y.

*GPL's *industrial-institutional TV* system.

IRE SHOW
BOOTH 1503

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For more information circle **76** on inquiry card.

For detailed information on GPL *ii-TV*

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Askania Regulator Company NEWS

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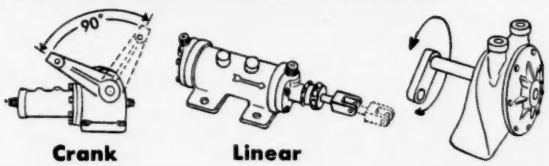
ELECTROJET® PROVIDES ½ H.P. TO 40 H.P. HYDRAULIC OUTPUT FROM LOW LEVEL ELECTRICAL INPUT

FROM TRANSDUCERS:

FOR PRESSURE • FLOW • RATIO • WEIGHT OR FORCE • SPEED • POSITION • TEMPERATURE • THICKNESS

TO THESE FINAL CONTROL ACTIONS:



Crank Moment **Linear Motion** **Rotation**

Note the Unique Advantages

The ELECTROJET offers those particular advantages only hydraulic power can provide:

1. Low Maintenance—Self Lubricated Parts
2. Output Power to Fill Needs from Smallest to Largest Requirements
3. Wide Range of Operating Speeds
4. Low Time Constants
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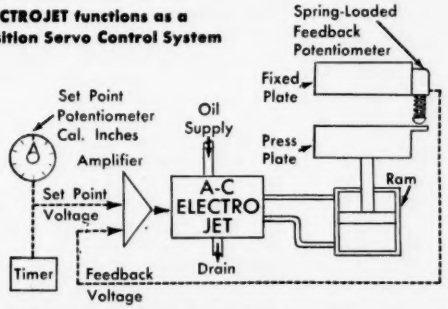
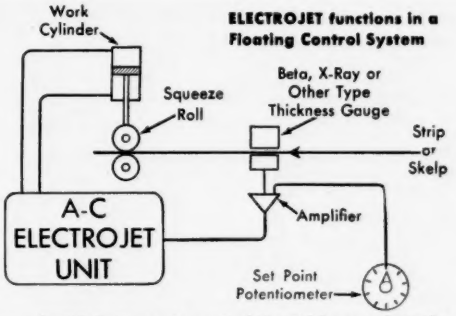
6. Convenient Safety Interlocks

ELECTROJET functions as a Position Servo Control System



In this instance to control the thickness of the sheet felt being produced on an hydraulic press.

ELECTROJET functions in a Floating Control System



In this instance to control the thickness of steel strip in a Rolling Mill

STUDY THESE SPECIFICATIONS

A-C ELECTROJET

Reference winding (constant).....115v, 0.15 amp, 50-60 cps
Control winding (variable).....0-115v, 0-0.15 amp
Break-loose voltage.....2v max.
Jet Pipe pressure.....110-150 psi std, 400 psi max.
Jet Pipe flow (examples)...1.2 mm nozzles; 100 psi, 0.6 gpm
2.5 mm nozzle; 400 psi, 5.2 gpm
Booster pressure.....2000 psi max.

D-C ELECTROJET

Maximum power input.....6 watts
Coil resistance.....5 ohms to 20,000 ohms
Break-loose power.....20 microwatts
Hydraulic specifications.....As for A-C Electrojet

Amplifiers for both A-C and D-C Electrojets are available to meet almost all requirements. However, in most applications the D-C Electrojet requires no amplifier.

Send for application bulletin No. 38.1

THE ASKANIA REGULATOR COMPANY APPLICATION BULLETIN NO. 38.1 contains
16 diagrams and illustrations to describe
1 available ELECTROJET types
2 applications and operation factors
3 types of Final Control elements, etc.
You'll want this bulletin for application... for study....for ready reference.

Write Askania Regulator Company, 268 E. Ontario Street, Chicago 11, Illinois

ASKANIA REGULATOR COMPANY

"CONTROLS FOR INDUSTRY"

HYDRAULIC, ELECTRONIC CONTROLS & SERVOS, GENERAL SYSTEMS, ENGINEERING & COMPUTER SERVICE, VALVE ACTUATORS & CYLINDERS

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For more information circle **78** on inquiry card.

Kearfott Servo Motor-Generators are characterized by low rotor inertia, low time constants and high stall torque. Motor-Generator combinations provide ½ to 3.1 volts per 1000 R.P.M. with an extremely linear output over a speed range of 0—3600 R.P.M. and useful output up to 10,000 R.P.M.

**New Size 11 low cost, Servo Motor-Damping Generator Type R 809.*

CHARACTERISTICS

TYPE	MOTOR		GENERATOR	
	STALL TORQUE	NO LOAD SPEED	OUTPUT FUND. NULL	LINEARITY
DAMPING				
SIZE 10	.35 OZ. IN.	6000	21/1	.5%
SIZE 10	.30 OZ. IN.	8500	23/1	.5%
NEW R 809	.63 OZ. IN.	5900	25/1	.5%
SIZE 15	1.5 OZ. IN.	5000	25/1	.5%
SIZE 18	2.4 OZ. IN.	5000	25/1	.5%
SIZE 18	3.0 OZ. IN.	9600	23/1	.5%
RATE				
SIZE 15	.45 OZ. IN.	10,500	170/1	.5%
SIZE 15	1.5 OZ. IN.	4700	350/1	.2%
SIZE 18	2.4 OZ. IN.	4700	350/1	.2%
SIZE 18	3.0 OZ. IN.	8400	350/1	.2%
***INTEGRATOR**				
SIZE 15	.70 OZ. IN.	6300	400/1	.1%
SIZE 15	1.25 OZ. IN.	4500	400/1	.1%
SIZE 18	1.35 OZ. IN.	7200	400/1	.1%
SIZE 18	2.4 OZ. IN.	5200	333/1	.06%
SIZE 18	3.0 OZ. IN.	8000	333/1	.06%

**Integrator Tachometers are temperature stabilized*

Kearfott components satisfy all requirements for high accuracy, light weight and small size.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Send for bulletin giving data of Counters and other components of interest to you.

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Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office: 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

For more information circle **79** on inquiry card.

power required by a typical tube. Resolution 10 microseconds. Counter can be preset from 1 to 500 for batch counting. In operation, output of a suitable pickup is fed to transistorized flip-flops which, when desired number is reached, cause an output relay to function.—*Nader Mfg. Co., 2661 Myrtle Ave., Monrovia, Calif.*

For more information circle **246** on inquiry card.

INTEGRATING COUNTER FOR PNEUMATIC TRANSMISSION

New seven-digit remote integrating counter for use with pneumatic transmission systems receives its signal from a measuring transmitter which operates on impulse duration system. Transmitted electric signal being a function of time, line voltage variations cannot affect counter's accuracy. Counter is housed in a small flush-mounting case for use near a pneumatic recording or indicating receiver, etc.—*The Bristol Company, Waterbury 20, Conn.*

For more information circle **247** on inquiry card.

DIGITAL DECADE COUNTER

New Digital Decade Counter, designed for use in manufacturers' electronic digitizing systems, provides high reliability while minimizing power requirements (6.3 vac @1.2 amp and 150-160 vac @7.5 ma); is available in two models, "369A" and "369B," which can be used as replacements for Brush "BD-100AN" and "BD-100BN" respectively. Function: it accepts input pulses at rates from 0 to 100,000 counts per second and generates one pulse at output for each 10 input pulses. Count is displayed by means of neon lights on a low-glare numerical screen. "Model 369A" has an octal base and analog staircase output; "369B" has an 11-pin base and four-line code out-put.—*Franklin Electronics Inc., Dept. 188, East 4th Street, Bridgeport, Pa.*

For more information circle **248** on inquiry card.

COUNTER-CONTROLLER

New industrial "MEK-2094-AG" will count dependably to 5,000 counts per second. At end of warning and final count, plug-in relays are ener-

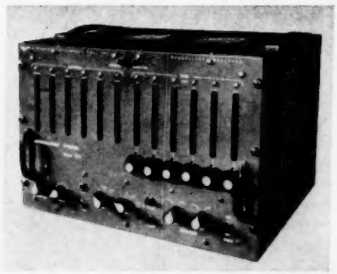
gized for control functions. Warning circuits can be used to slow down process to insure accurate control or to provide notice that preset number is about to be reached. At end of count, counter can be reset to zero manually (locally or remotely), or automatically either immediately or after an adjustable time delay. It is possible also to have counter reset immediately and have control relays remain energized until reset. These features in most cases obviate the need for a special controller. Unique enclosure design provides visible observation without opening; is dead front (NEMA 1) with door open.—*Machinery Electrification, Inc., Northboro, Mass.*

For more information circle **249** on inquiry card.

COMPUTING and DATA PROCESSING

ELECTRONIC INTEGRATOR FOR DATA REDUCTION

New "Model 270" accepts analog voltage signals, digitizes by heterodyne technique, and integrates area



under signal curve by counting at rate of 10,000 per second. Integral can be total area under curve, area above a preselected signal level, area under curve for a preselected time interval, etc. It provides highly accurate measurements of energy by integrating power *vs* time, impulse by integrating force *vs* time, etc.—*Allegany Instruments Co., Inc.,* 1091 *Wills Mountain, Cumberland, Md.*

For more information circle **250** on inquiry card.

DATA STORAGE UNIT

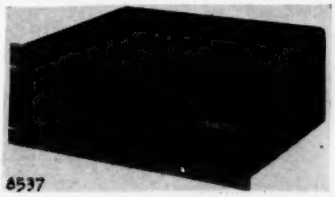
New "AD1 Delay Unit" accepts a pulsed input signal and delivers a delayed pulse output; operates at rep

rates up to 1 Mc; can be specified for delay periods up to 1100 usec. Maximum storage capacity 1100 bits of information; hence acoustical transmission is an economical storage method. Unit can be used with several types of digital equipment operating at a 91-ohm impedance level; is also completely compatible with maker's line of digital building blocks. Quartz delay medium is temperature-controlled for delay accuracies of 0.1 usec and can be adjusted by internal thermostat setting to provide fine control of delay period. A reverse gain control is provided for additional adjustments.—*Computer Control Co., Inc., Wellesley, Mass.*

For more information circle **251** on inquiry card.

CARD-TAPE CONVERTER FOR X-Y RECORDERS

New "Model 150" converts contact closures from an IBM punch, flexowriter tape, or maker's 10-key key-

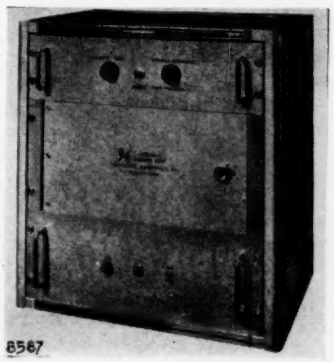


board, to proportioned resistance or voltage values. Data are programmed into converter memory by a control circuit which not only programs converter but interlocks machine during "read" cycle. This insures that only information is read into memory; errors due to stray pulses are eliminated. ★ "Model 250 Symbol Generator" is an optional attachment to Card-Tape Converter.—*Electro Instruments, Inc.,* 3794 *Rosecrans St., San Diego, Calif.*

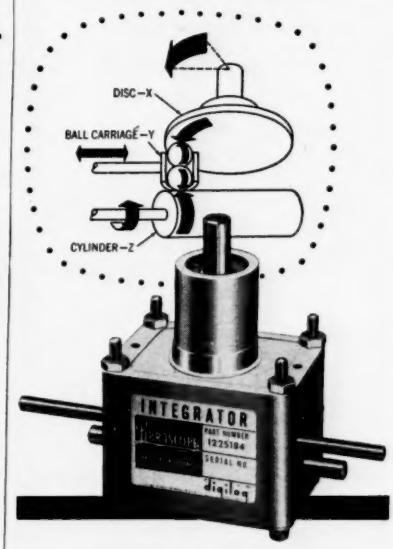
For more information circle **252** on inquiry card.

BUFFER STORAGE UNIT

New "1092-BU-7" coincident-current magnetic core storage unit is said to have "unique properties which make it ideal for application as a temporary store, buffer or delay unit in data processing, computing and automation systems." Capacity 1092 characters, each of which can be up to 7 binary digits in length: 7 bits of each character loaded and unloaded from memory in parallel; characters introduced into store sequentially and immediately available at output in



Primary parts of the Librascope Ball and Disc Integrator are a rotating input disc (X), two counter-rotating steel balls enclosed in a carriage (Y), and an output cylinder (Z). The cylinder speed is proportional to the product of the disc speed and the ball carriage position. The disc speed and ball carriage position can be continuously variable.



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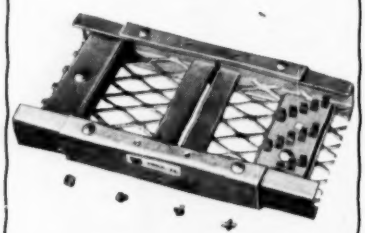

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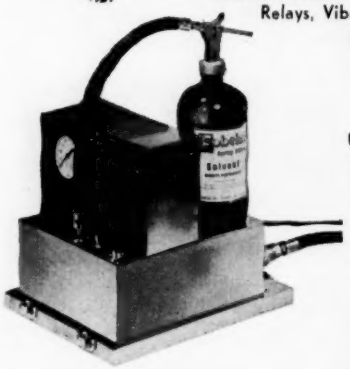

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the same sequence as loading sequence. No fixed block length for either loading or unloading.—*Telemeter Magnetics, Inc.*, 2245 *Pontius Ave., Los Angeles* 64, *Calif.*

For more information circle **253** on inquiry card.

PULSE TO ANALOG CONVERTER

New "Model 8915 Rotostepper" electromechanical shaft positioning device rotates shaft one 2° step per dc pulse. Rotation is unlimited clockwise or counter clockwise, and stepping speed is as rapid as 60 steps per second with torque output as high as 14 oz-in. Between pulses, shaft position is locked. Optional control mechanisms available on standard models provide homing to a fixed reference position, automatic continuous stepping with the application of a steady dc voltage, and/or voltage-divider output proportional to shaft position.—*G. M. Giannini & Co., Inc.*, 918 *E. Green St., Pasadena* 15, *Calif.*

For more information circle **254** on inquiry card.

RANDOM-VOLTAGE GENERATORS

New random-voltage generators, producing low-frequency noise with precisely controlled power frequency

spectra and predetermined amplitude probability characteristics, provide ultrastable accurate statistical functions for computer analysis, missile system analysis, transfer function derivation, etc. Six models cover frequency ranges from 0.01 to 50, 1000, 3000 and 5000 cps and to 1 and 5 Mc. Noise signal amplitude distribution with time is accurately Gaussian; output level 5 v rms into 600 ohms with direct reading calibrated attenuation.—*Intercontinental Dynamics Corp., Sigmatron Div.*, 170 *Coolidge Ave., Englewood, N. J.*

For more information circle **255** on inquiry card.

DELAY GENERATOR

New "Model 3770 Information Delay Generator," analog computer accessory, accepts input information in the form of a voltage varying with time and within limits −100 to +100 v; delivers the same information at its output terminals, but delayed 0.02-0.2 sec on lower range, or 0.2-2 sec on upper range. Delay interval, indicated within 1% on a large instrument, is smoothly and linearly adjustable by a single knob. Input waveform is faithfully reproduced for all frequency components from dc to inverse of delay interval. Two or more units can be cascaded for distortionless reproduction of higher frequencies, or to achieve proportionately greater time delays. ★ A second version provides a continuously adjustable delay up to 20 sec and principle can be extended to even longer delays.—*Donner Scientific Co., Concord, Calif.*

For more information circle **256** on inquiry card.

CURVE FOLLOWER FOR *X-Y* RECORDERS

New "Model 210 Curve Follower," is an integral, internal attachment for use on maker's *X-Y* recorders. Recorder pen is replaced with a pick-up coil which follows a fine wire bonded to graph paper. No physical contact is made between pick-up coil and curve. Wire is electrically excited by internal source. Connections are made at both ends of curve by miniature connectors. Over-all static accuracy is 0.25% full scale, except near sharp corners and at slopes greater than 75°.—*Electro Instruments, Inc.*, 3794 *Rosecrans St., San Diego, Calif.*

For more information circle **257** on inquiry card.

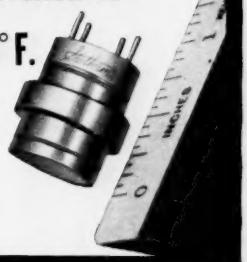
SYNCHRONOUS DIAL DRIVES FOR *X-Y* PLOTTING

New "X-Y Dial Drives" permit automatic sweeping techniques to be used with existing test equipment;

make it possible to use a two-axis plotter to obtain permanent and precise recordings of data. Tedious task of reading, logging, and plotting point-by-point values is eliminated. Two sizes of drives are available: for 4″ and for 6″ General Radio gear-driven precision dials. In each size two speeds are offered, one 8 times the other.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*

For more information circle **258** on inquiry card.

Miniature Pressure Transducers for operation to +400° F.



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NEW INSTRUMENTS

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New "Film-a-Record Model 11" photographs both sides of a document simultaneously at any of three reduction ratios; has a 12" throat, and doubles 16 mm film capacity by filming up one side and down the other using 8-mm principle. Capacity is 250 ft. of 16-mm film, which can be loaded in daylight. Automatic feeding equipment and document stacker available.—*Remington Rand*, 315 *Fourth Avenue, New York* 10, *N. Y.*

For more information circle **259** on inquiry card.

NUCLEONICS

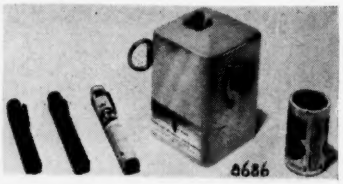
FIVE-DECADE SCALER

New "Model DS-5," said to be "the first scaler ever offered with five decade units," is a general-purpose nuclear lab instrument featuring "Mono-Matic" single-lever control which starts, stops and resets count and time, giving unusual simplicity of operation. Five decades, plus 100,000th unit indicator, permit direct count to 199,999 without external registers. Over-all resolution time is 1.0 usec per pulse pair. Pulse height control allows sensitivity to be varied to facilitate analysis of sample content.—*Technical Associates*, 140 *West Providencia Ave., Burbank, Calif.*

For more information circle **260** on inquiry card.

SAFETY DOSIMETER PENS & TRANSISTORIZED CHARGER

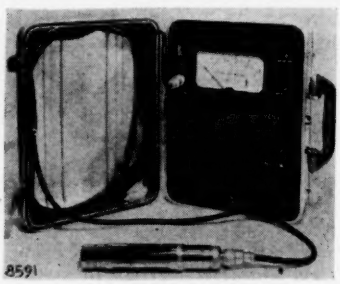
New lightweight dosimeter pens ranging from 200 mr to 100 r are direct-reading self-contained electrometers designed especially for protection of personnel. ★New "Model 44" charger utilizes maker's unique high-efficiency encapsulated transistorized power supply; is more rugged than conventional chargers because there are no neon regulators or glass of any sort (except for flashlight bulb); weighs less than a pound.—*Universal Atomics Corp.*, 143 *E. 49th St., New York* 17, *N. Y.*



For more information circle **261** on inquiry card.

RADIATION MONITOR

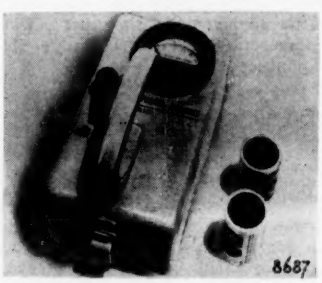
New "Model 420A" (console type) and "Model 420B" (suitcase type illustrated) all-purpose laboratory radiation detection monitor is said to be ideal for use in detecting alpha, beta (including carbon 14 and sulphur 35), and gamma radiation dosage, leakage, accidental spillage, and contamination. It can operate 24 hr a day, and can be set to sound an alarm and flash a light at a predetermined level of radioactivity. It operates from either 110 vac or from batteries; reads up to 50,000 cpm.—*Universal Atomics Corp.*, 143 *E. 49th St., New York* 17, *N. Y.*



For more information circle **262** on inquiry card.

RADIOLOGICAL SURVEY METER

New low-cost "Model 407" radiological survey meter for civilian defense units and laboratories with limited



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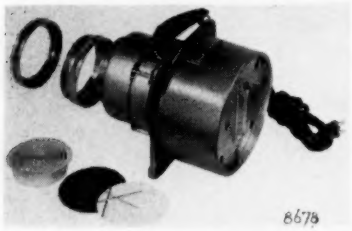
budgets, for surveying radiation dosage, leakage and contamination, indicates by pointer deflection, by flashing light and by earphone and, thanks to a high-gain transistorized circuit, is said to have greater efficiency than many more expensive instruments.—*Universal Atomics Corp.*, 143 *E. 49th St., New York* 17, *N. Y.*

For more information circle **263** on inquiry card.

HIGH VOLUME AIR SAMPLER

New high volume air sampler unit was developed in labs of New York Office of AEC for sampling large

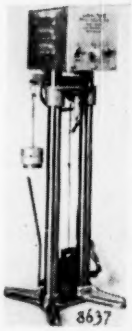


volumes of air for particulate matter by means of a filter paper; has successfully sampled air containing particles as small as one hundredth of a micron in diameter.—*Staplex Co., Air Sampler Div.*, 777 *Fifth Ave., Brooklyn* 32, *N. Y.*

For more information circle **264** on inquiry card.

LABORATORY EQUIPMENT

VISCOMETER



New "Hallikainen-Shell Sliding Plate Microviscometer" was principally developed to measure viscosity of asphalt, but can also be used on resins, plastics, and other viscous materials which will adhere to the glass sample plates. Among features: instrument can be used to measure asphalt durability or life expectancy as well as viscosity. Accurate measurements permit selection of asphalts with proper viscosity and great resistance to change.—*Hallikainen Instruments*, 1341 *Seventh St., Berkeley, Calif.*

For more information circle **265** on inquiry card.

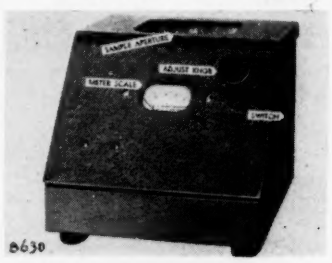
LAB VACUUM FURNACE

New "VA-L200C" laboratory arc-melting vacuum furnace (made by W.C. Heraeus GmbH, Hanau, West Germany) simulating conditions in a large production furnace features flexibility and easy operation; uses interchangeable consumable or non-consumable electrodes; can handle high-melting-point metals and many metallic carbides and borides; can be operated in either an inert atmosphere or in a vacuum down to 5×10^{-4} mm Hg; handles melts in "buttons" of a few ounces or ingots of several pounds; has two windows for observing crucible. A screw-type feeding device supplies crucible with sponge, powder, or granular material.—*Consolidated Electrodynamics Corp., Rochester Div.*, 1775 *Mt. Read Blvd., Rochester* 3, *N. Y.*

For more information circle **266** on inquiry card.

FLUORIMETER

New "Midget Fluorimeter" permits quantitatively measuring fluorescence simply, rapidly, and economically. Among features: (1) Numerical rating of fluorescence from 0 to 100; (2) luminosity filter to weight re-



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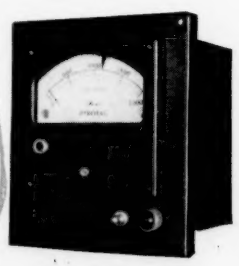

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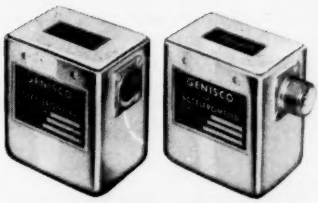
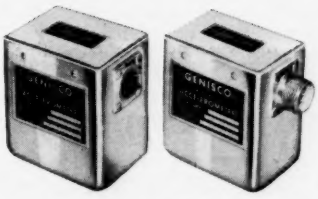


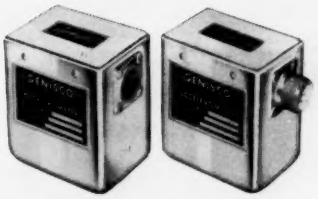
Model GLH

A rugged magnetically damped instrument with low natural frequencies for low range. High-quantity production assures good price and delivery schedules. Available in ranges from ±1 G to ±30 G.



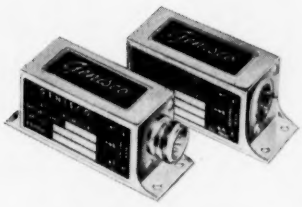
Model DDL

Magnetically damped low-range instrument available in ranges from ±1 G to ±30 G. Ultra-sensitive models supplied as low as ±0.1 G. Certified to MIL-E-5400 and MIL-E-5272A. Especially good in severe shock and vibration applications. An acceleration-sensitive switch version of the DDL is designated as the Model DDS.



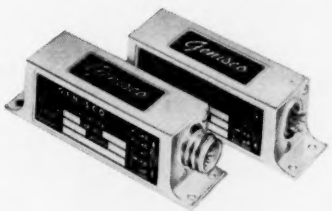
Model GAL

Incorporates a variable transformer a-c output with the magnetically damped sensory mechanism of the proven Models DDL and GLH. Superior reliability, life, resolution, and sensitivity. Available in ranges from ±1 G to ±30 G. Range as low as ±0.1 G also obtainable.



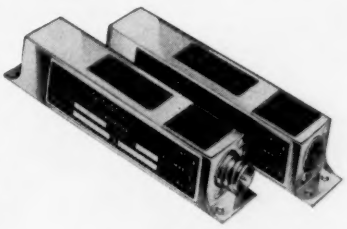
Model GMO

A rugged, miniature, viscous-damped instrument with ranges from ±2 G to ±30 G. Unbalanced-range instruments also available. Medium high natural frequencies.



Model GMT

Basically a Model GMO with internal thermostat-operated heater, assuring maximum environmental stability within the instrument. Damping remains constant with change in ambient temperature.



Model GDM

Miniature double-potentiometer instrument capable of sensing lateral acceleration in two mutually perpendicular planes (e.g., pitch and yaw). Ideally suited for missile and high-speed aircraft flight control systems.

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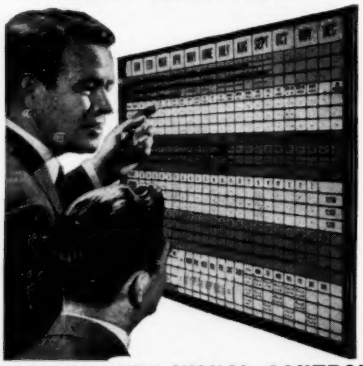

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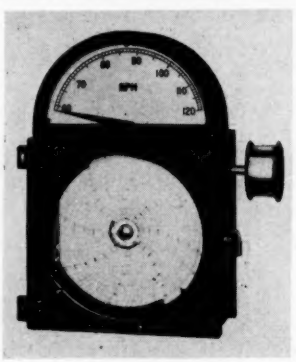

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NEW INSTRUMENTS

flectance to correspond to C. I. E. Standard Observer; (3) special filter to prevent invisible ultra-violet radiation from lamp or sample from affecting reading; (4) two exposure apertures for samples 3½" x 2¾" and 3" x 6"; glass plate for placing on top of exposure head when making measurements of dry powders, liquids in cells, or textiles; (5) reproducibility 2%.—*Gardner Laboratory, Inc., P.O. Box 5728, Bethesda 14, Md.*

For more information circle **267** on inquiry card.

FLUORIMETER

New "Model FL-210 Fluorimeter," for quantitative analysis of uranium minerals, and for uranium determina-

tions in geobotanical, hydrogeochemical and geochemical prospecting, works over a wide range of ambient temperatures and input voltages and thus is suitable for both field and lab use. Reading in micrograms of uranium is obtained direct from a large ten-turn dial.—*Mt. Sopris Instrument Corp., 1320 Pearl Street, Boulder, Colorado.*

For more information circle **268** on inquiry card.

HOT-PLATE & MAGNETIC-STIRRER COMBINATION

New "Thermix" combination 700-watt heater and magnetic stirrer cuts hours from a host of routine stirring

mixing and dissolving operations. Hotplate and stirrer can operate independently or simultaneously. A continuously-variable (not on-off) bimetallic thermostat directly controls top-plate temperature, eliminating possibility of excessive temperature overshoot. A continuously-variable control regulates stirrer speed up to 900 rpm under load. Glass-covered and Teflon-covered stirring magnets.—*Fisher Scientific 461 Fisher Building, Pittsburgh 19, Penna.*

For more information circle **269** on inquiry card.

UNIVERSAL PHOTOMETER

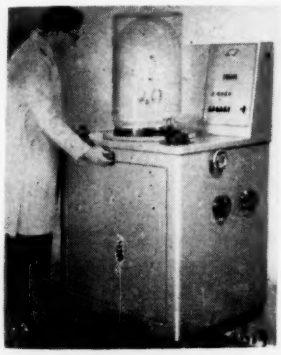
New "PH-200 Universal Photo-multiplier Photometer," said to be "the first photometer capable of utilizing

the maximum performance characteristics of any commercially-available photomultiplier or phototube," incorporates a highly-regulated electronic power supply; is completely self-contained and portable; features separate zero and dark-current adjustments as well as both decade and continuously variable sensitivity controls, also provision for 'scope and recorder readout; comes ready for use with type 931-A photomultiplier tube others available on special order.—*El Dorado Electronics Co., 1401 Middle Harbor Rd., Oakland 20, Calif.*

For more information circle **270** on inquiry card.

LAB VACUUM UNIT FOR COATING AND DEGASSING

New "Type LC1-14A" vacuum system for lab, pilot plant, and limited production use, was designed primarily for lab coating of various materials with vaporized metals; unit is also useful for degassing liquids, crys-



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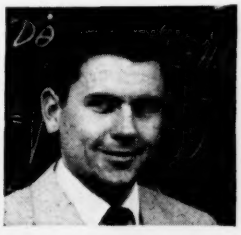
THREE AUTONETICS ENGINEERS ON THEIR WAY UP

In just 6 years, Elliott Buxton has risen from Servo Research Analyst to Group Leader responsible for Preliminary Engineering in Autonetics' Flight Control Program. Among his other professional achievements, "Buck" has several patents filed in his name—including an aircraft maneuver stabilizer and a load-factor anticipation switch.

Ronald Greenslade (BSEE Michigan) is Group Leader in charge of development and design of electro-mechanical components for aircraft armament control systems at Autonetics. From Southern California's many fine residential communities, Ronald chose Long Beach, where he lives with his wife and two young daughters.



Dave Kimball joined Autonetics in 1950 with a BSEE from the University of New Mexico. Only 29, he is already Group Leader in the challenging field of Inertial Guidance Engineering. Dave lives with his wife and two children in nearby Fullerton, California—an ideal center for his favorite diversions: softball, bowling and skin-diving.

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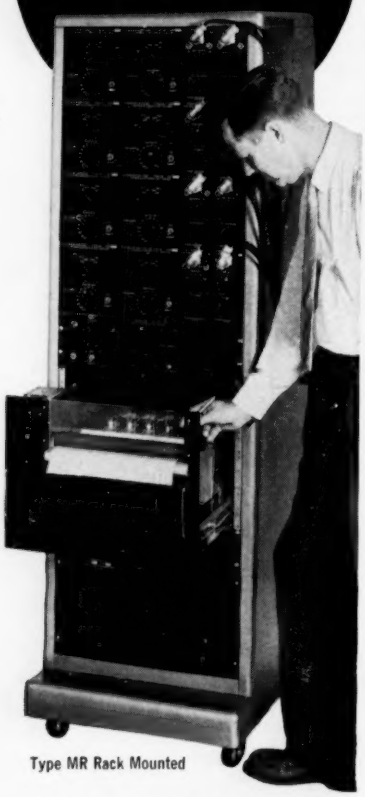

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NEW INSTRUMENTS

tal pulling and growing, melting small metal samples, and degassing vacuum-tube electrodes; it features a high-capacity pumping system which reduces pumping time, and a complete line of standard accessories.—*Consolidated Electrodynamics Corp., Rochester Div.*, 1775 *Mt. Read Blvd., Rochester* 3, *N. Y.*

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ELECTRICAL TESTING

UNIVERSAL RELAY TESTER

New "Universal Relay Tester" will check relays for pull-in and drop-out voltage and current requirements,

contact operation and insulation condition by hi-potting. All tests are accomplished by simple operation of a few switches and controls. Relay conditions are shown by indicator lights. —*Magnavox Co., Dept. NP, Fort Wayne* 4, *Indiana.*

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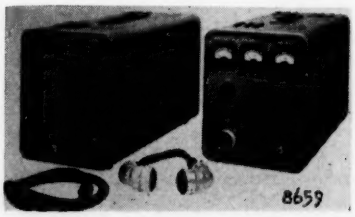
WIDE-BAND OSCILLATOR

New "Model 1141 Power Oscillator" has high output: over 40 watts from 200 to 400 Mc; 25 w from 400 to 1000 Mc and 10 w from 1000 to 2500 Mc. Frequency range is covered in two overlapping bands: 200-1050 and 950-2500 Mc. Calibration accuracy is 1% or 5 Mc, whichever is greater; resettability is better than 0.1%. Oscillator provides square-wave or sine-wave modulation from built-in 400-cps and 1000-cps sources; allows modulation at other frequencies from a suitable external source. Modulation level and rf output level are adjustable over wide ranges.—*The W. L. Maxson Corp.*, 47-37 *Austell Place, Long Island City* 1, *N. Y.*



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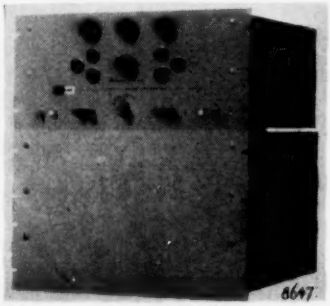
INSTRUMENT CALIBRATOR

New improved "Model M100A-20 Meter Calibrator" provides dc from 0 to 1000 at 0 to 200 ma with 0.01%



SEMI-AUTOMATIC MASS-PRODUCED COMPONENT TESTER

New "Model 815 1000-Specimen Capacity Automatically Recording Life Test Set" permits fast, accurate mass life testing of vacuum tubes, transistors, etc; is highly flexible; will perform simultaneously many different types of tests on various different types of components, with (1) automatic digital readout of operating current data about all specimens being tested, in sequence, and at predetermined times, in both visual and typewritten form; and (2) manually-commanded digital readout about any specimen at any time, in both visual and typewritten form. Minimum installation: 200-specimen system.—*Systems Development, Inc.*, 307 *Water St., Binghamton, N. Y.*

For more information circle **274** on inquiry card.

ELECTRONIC SLIDE RULE ILLUSTRATES SUPERIORITY OF BORG MICROPOTS

LOADING ERROR SOLVED BY BORG

Loading error, an important consideration in many potentiometer applications, has been solved by Borg.

LOADING ERROR DEFINED

Loading error is caused by current flow through the contact arm to a finite value of resistance (RL) connected to the output terminals of the pot. Ratio of total resistance of the pot to the load resistance determines the linearity error caused by the load. (Fig. 2).

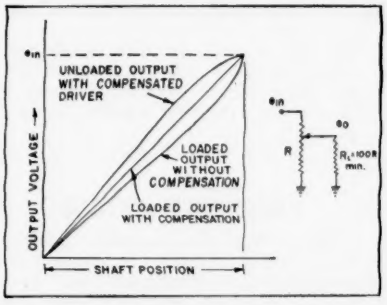


Fig. 2—Series resistance adjustment to minimize loading error.

PARTIAL REMEDIES

Fig. 2 shows a restriction of the usable portion of the pot to the relatively flat portion of the curve. This requires trimming resistors and at best makes use of less than ⅔ of the total rotation.

Another method is to tap the resistance wire at the point of maximum load error and make straight line approximations by use of a padding resistor (RP), Fig. 3. Load error is not entirely eliminated and the cost of the tap, selection and installation of the trimmer, is substantial.

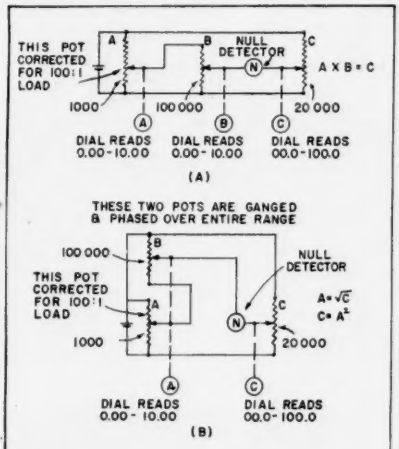


Fig. 1—Electronic slide rule for multiplication (A) and for squares and square roots (B).

THE ELECTRONIC SLIDE RULE

Electronic slide rule. (Fig. 1) was designed to illustrate this correction method in an actual application. It is not possible without two features found only in Borg's 900 Series, accurate load correction over the entire range of 0 to 100%, in pot A, and absolute linearity on all pots. The ganged assembly of pots A and B shown in (B) phased over entire range, illustrates another valuable feature of the Borg 900 Series Micropot Potentiometer.

THE BORG METHOD

The Borg method of eliminating load error is made possible by the design of the Borg 900 Series Micropot. Loading error correction is built into the potentiometer by means of an integral nonlinear actuator contact drive. It is computed to introduce motion equal in magnitude and opposite in sign to the error of a given load ratio. (Fig. 4).

This method provides accurate load correction over the entire range of 0 to 100% without trimming or tapping. Dual correction can be made when the application requires positive and negative values from a center tap.

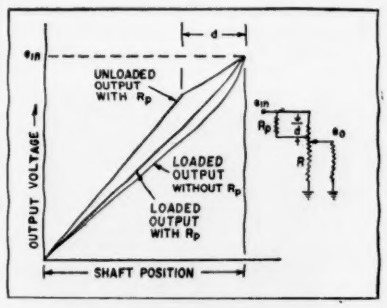


Fig. 3—Preloading to minimize loading error.

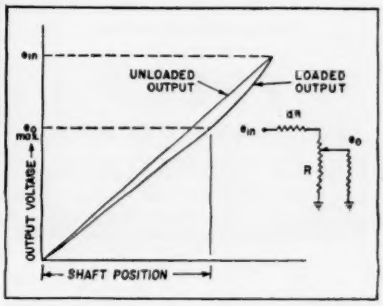


Fig. 4—Compensated drive to offset loading error, 100:1 ratio.

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MGP3	650	√	245	.150	6.3	5	5.0	3	KB
MGP4	800	√	318	.175	5.0	3	6.3	8	LB
MGP5	900	√	345	.250	5.0	3	6.3	8	MB
MGP6	700	√	255	.250					KB
MGP7	1100	√	419	.250					LB
MGP8	1600	√	640	.250					NB

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MPT1	√	√		0.25/0.25/0.25	0.2-1.0	.004	3	0.7	250
MPT2	√	√		0.25/0.25	0.2-1.0	.004	2	0.7	250
MPT3	√	√		0.5/0.5/0.5	0.2-1.5	.002	3	1.0	250
MPT4	√	√		0.5/0.5	0.2-1.5	.002	2	1.0	250
MPT5	√	√		0.5/0.5/0.5	0.5-2.0	.002	3	1.0	500
MPT6	√	√		0.5/0.5	0.5-2.0	.002	2	1.0	500
MPT7	√	√	√	0.7/0.7/0.7	0.5-1.5	.002	3	1.5	200
MPT8	√	√	√	0.7/0.7	0.5-1.5	.002	2	1.5	200
MPT9	√	√	√	1.0/1.0/1.0	0.7-3.5	.002	3	2.0	200
MPT10	√	√	√	1.0/1.0	0.7-3.5	.002	2	2.0	200
MPT11	√	√	√	1.0/1.0/1.0	1.0-5.0	.002	3	2.0	500
MPT12	√	√	√	0.15/0.15/0.3/0.3	0.2-1.0	.004	4	0.7	700

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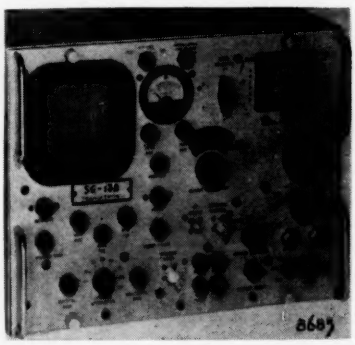
NEW INSTRUMENTS

long-time stability, 0.01% line and load regulation, 0.2 ms response time, 0.05% calibration tolerance, less than 2 mv hum and noise, and less than 0.01 ohm output impedance. High gain chopper amplifiers constantly compare output voltage with an internal standard cell. Direct-reading calibrated dials permit instant selection of desired output voltage. Outputs are provided for both regulated voltage and current.—*Kay Lab, 5725 Kearny Villa Road, San Diego 11, Calif.*
For more information circle **275** on inquiry card.

VHF-UHF SWEEP GENERATOR

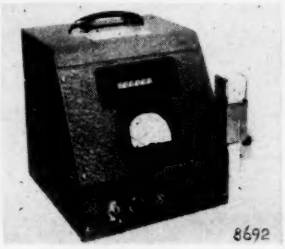
New "Model SG-132" combines all essential features of a standard CW and AM signal generator and a wide band sweep generator of unusual characteristics; offers wide sweep width: 40% of center frequency, from 15 to 400 Mc, with dial accuracy



0.01%, crystal corrected. Output (entirely fundamental, not beat-frequency oscillators) is calibrated from 0.1 to 150,000 uv throughout frequency range. Unusual feature is constancy of this output which varies less than 0.2 db over entire range.—*Transitron, Inc., 186 Granite St., Manchester, N. H.*
For more information circle **276** on inquiry card.

INSULATION TESTER

New "P-1" tester counts insulation faults (pinholes) in insulated wire at speeds up to 600 fpm for continuous



production use. For use as an insulation continuity tester, it features continuous display of total number of pinholes; audible alarm; continuously adjustable voltage control and panel setting for single or multiple coated wire; small moistened sponge electrode (uses tap water, not mercury); small test current (10 amp) will not mar finest wire and will detect through 10 megohms.—*Peschel Electronics Inc., 9 Garden St., New Rochelle, N. Y.*
For more information circle **277** on inquiry card.

ELECTRICAL & ELECTRONIC INSTRUMENTS

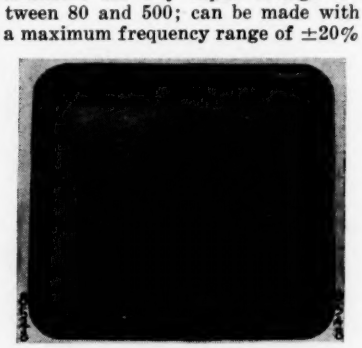
DIGITAL VOLT-OHMMETER

New low-cost "Digital Multimeter" measures volts and ohms with 0.5% absolute accuracy (0.1% accuracy

when using external standards). Ranges: 0.01 to 1000 v ac or dc, and 10 ohms to 10 megohms; on ac measurements up to 100 kc with standard probe and up to 150 Mc with an accessory probe. In measuring either voltage or resistance, any 3 ranges, each with a sensitivity of 0.1% can be selected manually. Reading rate (20 per second) permits monitoring rapidly-varying voltages without pmmc phase lag.—*Franklin Electronics Inc., Dept. 210, East 4th St., Bridgeport, Pa.*
For more information circle **278** on inquiry card.

FREQUENCY METERS

New "E.I.C." frequency meters (made in Scotland) are direct-indicating, can be made for any frequency from 40 to 10,000 cps; are available for any input voltage between 80 and 500; can be made with a maximum frequency range of ±20%



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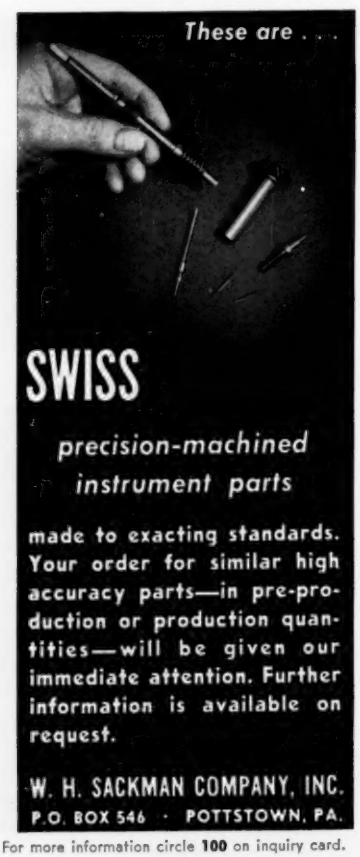
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For more information circle **100** on inquiry card.

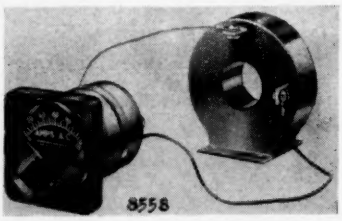
NEW INSTRUMENTS

from any specified center frequency. Owing to design of network with two twin "T" bridges, all harmonics cancel and indication is more independent of wave-form than that of any other pointer-type frequency meter.—*Gary Wells Co., 3 Park Row, New York 38, N. Y.*

For more information circle **279** on inquiry card.

LINEAR-SCALE AMMETERS

New ammeters with evenly-graduated scales have passed qualification tests: extreme vibration, shock, moisture, salt spray and fungus over a wide range of operational conditions, from sea level to 50,000 ft, from −55°C to 71°C. Standard range 0-115 amp. Standard model is designed for use on a 200/115-v 3-phase 400-cps system; special models can be supplied for other applications. Each ammeter is supplied with a 5-ma rat-



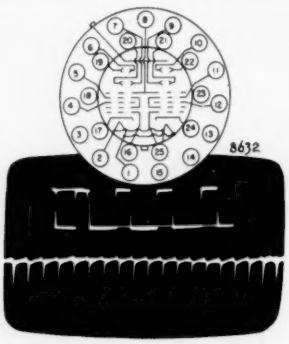
ing transformer using as its primary a generator-output bus bar or other current conductor. Transformer can be located 150 ft or more from ammeter without any noticeable effect on accuracy.—*Beckman/Helipot Corp., Newport Beach, Calif.*

For more information circle **280** on inquiry card.

ELECTRICAL-INSTRUMENT ACCESSORIES

TWO-GUN CR TUBES

New rectangular-faced two-gun cathode ray tubes with high electrostatic deflection sensitivity feature in-

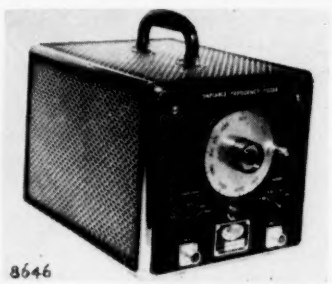


dependently-controlled guns; employ post acceleration, electrostatic focus, and long-persistence orange phosphor. Two types: "7ALP19" with a phosphor that eliminates initial blue flash of P7 often used in radar indicators; and "7ALP25" with a burn-resistant phosphor of longer persistence than P19.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **281** on inquiry card.

VIBRATION-STUDY FILTER

New "Model 1065 Continuously Variable Filter," designed for use with maker's Vibration Analyzers, provides facility for analyzing vibration at all frequencies from 5 to 5000 cps. By tuning filter to desired frequency or by scanning vibration frequency spectrum, mechanical trouble reflected as vibration can be quickly spotted without costly dismantling. For correcting, portable analyzer and filter combination is used for "in-place" balancing. Band-width throughout range is about ±5% of nominal frequency to 3-db down points. This extraordinary sharpness is advantageous for pin-pointing various frequency compo-

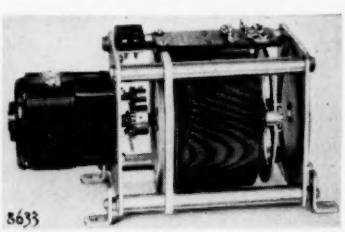


nents present in a complex vibration. —*International Research & Development Corp., 797 Thomas Lane, Columbus, Ohio.*

For more information circle **282** on inquiry card.

MOTOR DRIVES FOR AUTOTRANSFORMERS

New motor drives in a wide variety of speeds, suitable for servo work as well as for remote-positioning appli-



cations, are offered for recently announced "W2" and "W5" models of maker's "Variac" autotransformers. Ganged "Variacs" as well as single units can be supplied with motor drives in open or completely enclosed

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For more information circle **101** on inquiry card.

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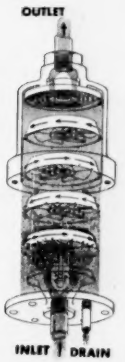
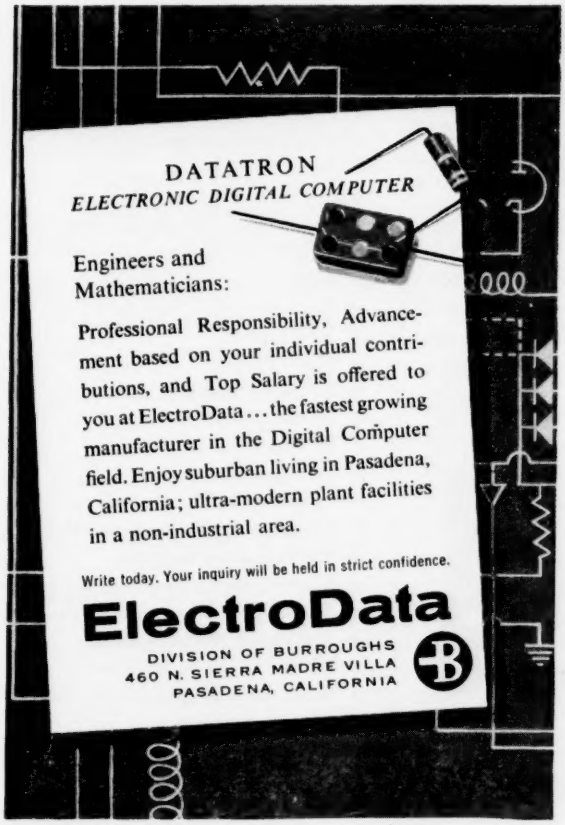
Learn how the engineered-to-your-line ARIDIFIER can solve your problem and save you trouble and money. Write for the Aridifier catalog.



Exploded view showing ARIDIFIER operation. Capacities, 7 to 17,000 C.F.M.

Logan ENGINEERING CO.
4921 West Lawrence Avenue, Chicago 30, Ill.

For more information circle **102** on inquiry card.



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GERMANIUM
INDIUM ANTIMONITE
INDOX
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STRONTIUM TITINATE
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*VYCOR
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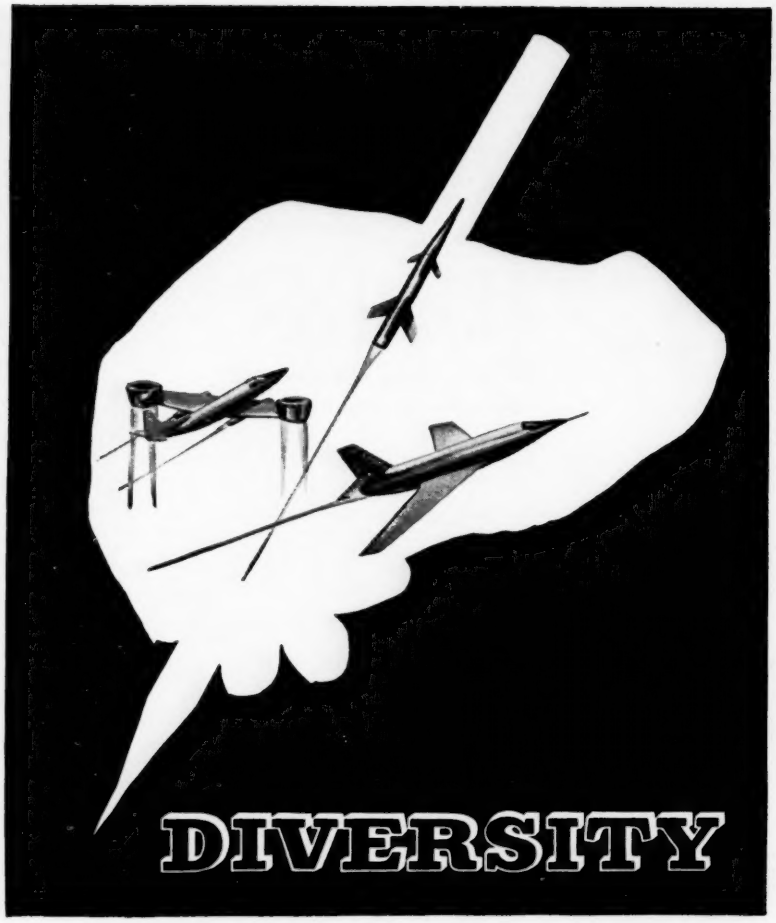
ALL TYPES KNOWN GLASS

*Carried in stock
**Purchased for orders

For more information circle **103** on inquiry card.



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- **Mechanical Engineers**
- **Microwave Engineers**
- **Miniturization Engineers**
- **Operations Analysts**
- **Physicists**
- **Power Plant Designers**
- **Pressure Vessel Designers**
- **Project Engineers**
- **Publication Engineers**
- **Radar Systems Engineers**
- **Rocket Test Engineers**
- **Servo Systems Engineers**
- **Servo Valve Engineers**
- **Statisticians**
- **Stress Engineers**
- **Structures Engineers**
- **Specification Writers**
- **Technical Writers**
- **Test Equipment Engineers**
- **Transformer Design Specialists**
- **Transistor Application Engineers**
- **Thermodynamic Engineers**
- **Telemetering Engineers**
- **Turbine Pump Designers**
- **Vibration & Flutter Analysts**
- **Weapons Systems Engineers**
- **Wave Guide Development Engineers**
- **Weights Engineers**

mountings. Full-scale traverse rates of 4, 8, 16, 32, or 64 sec are available on all "Variac" models, and a drive with a 2-sec traverse can be had on "W2," "W2G2," or "W5."—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **283** on inquiry card.

AMPLIFIERS

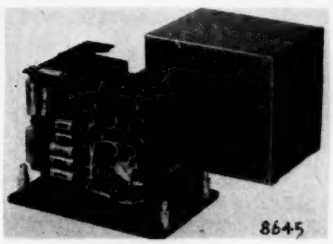
MAGNETIC AMPLIFIER

New "Model D-4 Blue Line Premium Amplifier" is designed to deliver 4 watts half-wave 400 cps to BuOrd MK14 servomotor or equivalent. Features: silicon diodes, heavy formvar magnetic wire, control windings for both transistor and vacuum-tube preamplifiers. Voltage gain (tube) 4; response one cycle or less of supply frequency; temperature range −65°C to 125°C.—*Feedback Controls, Inc., 899 Main St., Waltham 54, Mass.*

For more information circle **284** on inquiry card.

SERVO AMPLIFIERS

New complete line of servo amplifiers, for 60- and 400-cps servomotors from 1 to 50 watts, features universal



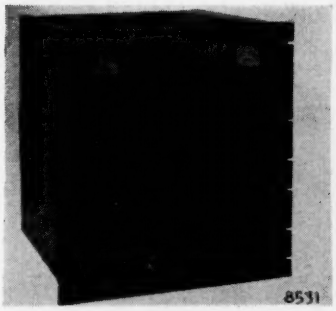
characteristics and flexible input circuits. Circuit techniques range from vacuum tube to transistor-magnetic. Four packaging styles include hermetic sealing, and plug-in quick-disconnect packages. Most amplifiers operate directly from power lines.—*Industrial Control Co., Wyandanch, L. I., N. Y.*

For more information circle **285** on inquiry card.

POWER SUPPLIES, etc.

H-V POWER SUPPLY

New "Model 4K-100B," for use with high-voltage tubes, klystrons, photomultipliers, etc., delivers 400 to 4000 vdc, continuously variable without switching, 0 to 100 ma. Regulation for output voltage range of 2000 to 4000 vdc is 0.1% NL to FL; below



2000 vdc, 0.25% NL to FL. For line voltage of 115 vac ±8%, change in output voltage from 2000 to 4000 vdc is 0.15%, below 2000 vdc, 0.3%. Ripple and internal noise are below 5 mv rms for any voltage or load within rating.—*Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.*

For more information circle **286** on inquiry card.

AIRBORNE POWER SUPPLY

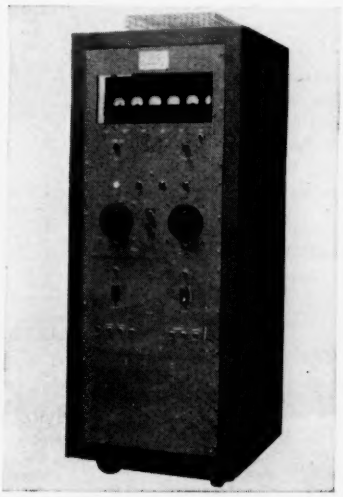
New "MRP 22.1" line-transient-free short-circuit-proof airborne power supply provides 22.5 vdc, 0-100 ma,

for various telemetering and instrumentation applications; operates from 95-135-v 380-420-cps aircraft main; drives from 10 to 12 of maker's "MMO-522" amplifiers. Line-transient-free performance is provided by maker's exclusive dual magnetic regulation.—*Magnetic Research Corp., 202 Center St., El Segundo, Calif.*

For more information circle **287** on inquiry card.

KLYSTRON POWER SUPPLY

New "Model PC 51," for klystrons with bombarded cathodes, provides 0-3 kvdc at 0.9 amp with less than



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Scam sequential annunciator systems provide an audible and flashing visual signal on the first alarm to enable the operator of your control board to determine which point in the monitored process first becomes abnormal . . . successive alarms that develop from the original abnormal condition are indicated by a steady visual signal. You can take proper corrective measures immediately because you know where the trouble started.

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For more information circle **98** on inquiry card.

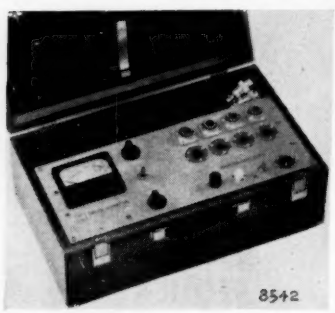
NEW INSTRUMENTS

0.5% ripple, 0-20 vac at 60 amp and 0-750 vdc at 20 ma.—*Levinthal Electronic Products, Inc., 905 Stanford Industrial Park, Palo Alto, Calif.*

For more information circle **288** on inquiry card.

REGULATED POWER SUPPLY

New "Model 2621" regulated and filtered power supply, for use with maker's acceleration, vibration, pressure and force measuring systems, satisfies single-channel instrumentation needs with capacity for expansion; provides 1% regulated B+voltage between 100 and 180 vdc and filament voltage of 6 vdc with extremely low ripple.—*Endevco Corp., 161 E. California St., Pasadena, Calif.*



For more information circle **289** on inquiry card.

DUAL-RANGE POWER SUPPLY

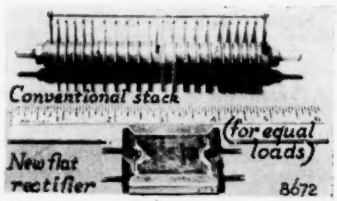
New "Model KM95B" has a continuous duty rating of either 0-32 vdc at 40 amp or 0-64 vdc at 20 amp. Ripple is held to within 1% of average dc at maximum output. Unit operates on either 115 or 230 vac 60-cps single-phase. To prevent accidental switching, line voltage selector is equipped with a special safety locking device. Bench cabinet or rack mounting.—*Opad Electric Co., 69 Murray St., New York 7, N. Y.*

For more information circle **290** on inquiry card.

RECTIFIERS

FLAT SELENIUM RECTIFIER

New flat selenium rectifiers, smaller and lighter than comparable stack assemblies but providing equal or more power, are made by Siemens (West Germany). Utilizing heat sink principle, they are mounted directly on chassis which draws off heat, can be tucked away in a corner of instrument, receiver, etc., without having to allow for air to circulate among plates. Available in half-wave and bridge, in a variety of sizes.—*Radio Receptor Co., Inc., Semiconductor Div., 240 Wythe Ave., Brooklyn, N. Y.*

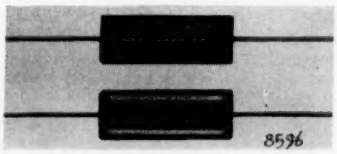


For more information circle **291** on inquiry card.

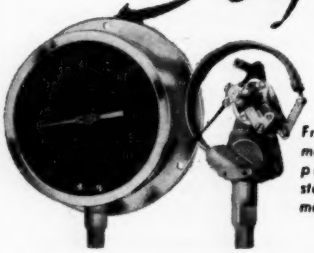
FIXED RESISTORS

FILM RESISTORS

Two new models in maker's line of "Vamistors" (thermally fused metal film resistors) make available numerous 0.5-watt and 1-watt units with resistance values from 1000 to 100,000 ohms. Special resistance alloy used



FOR EXTRA *Safety*



Front view and internal mechanism of Type 917 RR pressure gauge with stainless steel bourdon, movement and socket.

For extra safety in the presence of corrosive acids or fumes Weksler now makes available a complete line of STAINLESS STEEL Gauges in four standard sizes — Type 916 RR with stainless steel bourdon and alloy steel socket, or Type 917 RR with all stainless steel bourdon and socket.

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For more information circle **90** on inquiry card.

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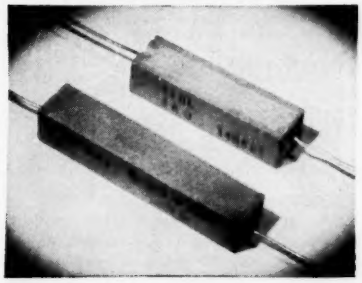
For more information circle **91** on inquiry card.

in "Vamistor" is fused into inner surface of moisture-sealed ceramic tube by a new electrothermal technique which creates a glass-hard embedded resistance element that will withstand abrasion, thermal shock and temporary overloads without change.—*Weston Electrical Instrument Corp., Newark* 12, *N. J.*

For more information circle **292** on inquiry card.

SQUARE-BODY MINIATURE POWER RESISTORS

New "Series C7GL and C10GL" feature wire-wound resistance element placed in a square-body steatite

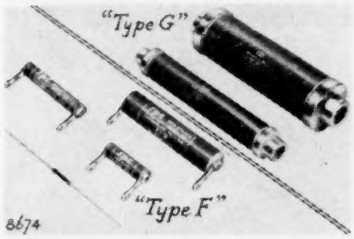


casing and imbedded and sealed in inorganic cement. Available in 7- and 10-watt ratings, 1⅜" and 1⅞" long; resistance values from 1 ohm to 6,000 ohms, and 1 ohm to 11,000 ohms, respectively.—*Clarostat Mfg. Co., Inc., Dover, N. H.*

For more information circle **293** on inquiry card.

HIGH FREQUENCY RESISTORS

Two new lines of hf resistors are for use where requirements call for extremely low inductance, capacitance



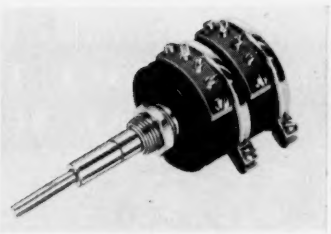
and skin effect in circuits involving pulses and steep wave fronts. Depending on size and resistance value, new units are usable at frequencies to over 400 Mc. Resistance values 20 ohms to 100 megohms; tolerance 20% to 5%. "Type G (high frequency)" 6 sizes, 10 to 100 watts; "Type F (high frequency)" 8 sizes 1/4 to 10 watts.—*Resistance Products Co., 914 S. 13th., Harrisburg, Pa.*

For more information circle **294** on inquiry card.

VARIABLE RESISTORS

CONCENTRIC-SHAFT VDR's

New voltage-dividing resistors feature new concentric-shaft design which permits two VDRs to be single-hole mounted for control by a dual

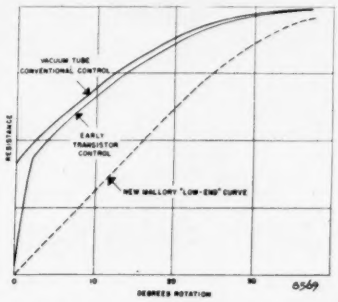


knob. Standard ⅛" and ¼" shafts; assembly is mounted by usual ⅜" threaded bushing or can be supplied with servo-style mounting.—*Waters Mfg., Inc., P.O. Box* 368, *South Sudbury, Mass.*

For more information circle **295** on inquiry card.

VOLUME CONTROL

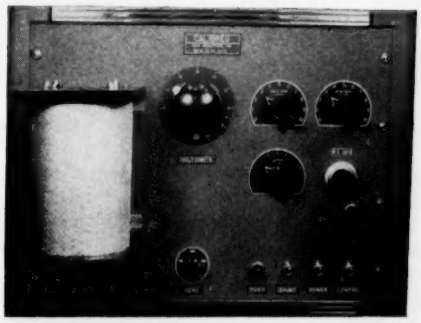
New printed-circuit-type volume control, with a special low-end resistance taper designed for use with transistors in printed circuits, fea-



THERMOCOUPLE CALIBRATOR

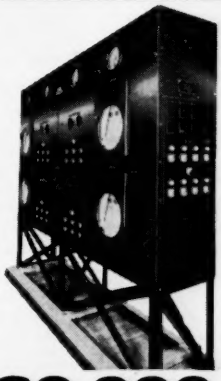
PRECISION CONTROLLED OVEN
ACCOMMODATES SIX THERMOCOUPLES
OR THERMOMETERS AT ONE TIME

Temperature Setting to .01°C.
Temperature Control to .01°C.
—100°C. to 1000°C.



RAM INDUSTRIES, INC.
152 West 42nd Street, New York City
Wisconsin 7-2971

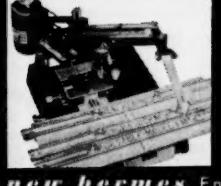
For more information circle **96** on inquiry card.



THE $20,000 DELAY

For want of a simple nameplate, the Automatic Temperature Control Co., Philadelphia, had to hold up shipment of $20,000 in control equipment.

Now, a portable Engravograph (size of a typewriter) makes individual nameplates on the premises. Cost, per label, less than 50¢—with unskilled labor.



Engravograph

Keeps skilled labor at skilled jobs. Solves many marking problems. 16,000 now in use. Pays for itself.

WRITE FOR LITERATURE DEPT. NO. IM-37

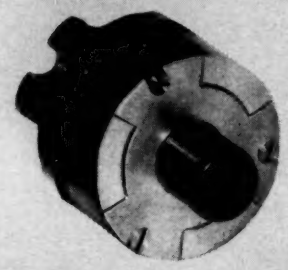
new hermes Engraving Machine Corp.
13-19 University Pl., New York 3, N.Y.

HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE

RBM

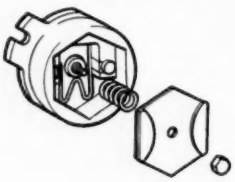
MOTOR PROTECTOR

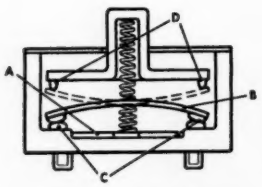
AUTOMATIC RESET—#91300, #91400



MANUAL RESET—#92300, #91400

A PRODUCT OF RBM DIVISION OF
ESSEX WIRE CORP
LOGANSPORT, IND.





After years of development by RBM Division of Essex Wire Corp., and now in volume production, this bimetal motor over-load protector provides overload protection for split phase or capacitor motors such as are used in many household appliances. It may also be used with 110/220 volt motors of heavier capacity. The disc-type element is sensitive so as to give instant response to locked rotor current, yet carry starting surges and protect against running over-loads. The calibration to trip at 105° (also 120°) allows for ambient compensation for varying temperatures within the motor. The box shape of the terminals prevents soldering spatter and the double break contact provides long contact life. The snap-action disc element is fabricated from Chace Thermostatic Bimetal.

Here's how the manual reset protector works: The heater wire (A) carries a normal load but is heated by locked rotor currents or running overload currents. The heater in turn heats the thermostatic bimetal disc element (B) until at the calibrated temperature it snaps into the reverse shape, opening the contact points (C); when the reset plunger is depressed after correction of the failure, the two buttons (D) contact the bimetal element, forcing it to snap back into its original shape with contacts closed.

Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1609 BEARD AVE., DETROIT 9, MICH.

For more information circle **104** on inquiry card.

tures extremely low "hop-off" or zero rotation resistance. In addition, low end taper gives gradual resistance rise from zero point over first 20° to 30° of shaft rotation, providing smooth control throughout entire volume range. New taper is available on controls of various styles.—*P. R. Mallory & Co. Inc., 3029 E. Washington St., Indianapolis 6, Ind.*

For more information circle **296** on inquiry card.

SUBMINIATURE VDRs

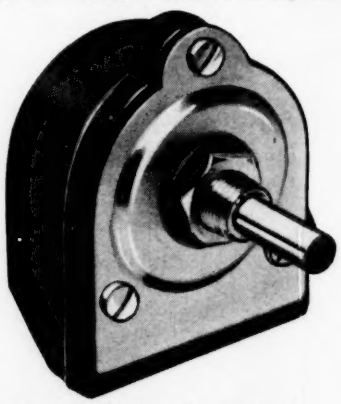
New "Acepot" subminiature precision wire-wound voltage-dividing resistors, with resistance range from

10 ohms to 250 k and linearity of 0.3% are said to "match the quality, dependability and performance usually found only in much larger units." Weight ¼ oz; power 2 watts for 60°C rise; extremely high resolution; ambient temperature −55°C to 150°C; one-piece precision machined aluminum case; available in standard threaded bushing, servo or flush mountings, and ganged units.—*Ace Electronics Associates, Inc., 103 Dover St., Somerville 44, Mass.*

For more information circle **297** on inquiry card.

VARIABLE RESISTOR

New "Type H" 5-watt molded composition variable resistor is especial-



ly suited to industrial electronic applications.—*Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis.*

For more information circle **298** on inquiry card.

SINGLE-TURN VDR

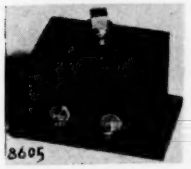
New "13-100-1" single-turn voltage-dividing resistor, with operating temperature range of −55°C to 100°C has many instrumentation and general servomechanism uses because of its compact size ($1\frac{5}{16}$D x $\frac{57}{64}$L), lin-

earity as close as 0.25%, low noise level, adaptability to both mechanical and manual settings, and low torque (0.5 oz-in). Total resistance range 50 to 40,000 ohms. Dimensional stability, impact strength and heat dissipation are provided through one-piece anodized aluminum alloy housing. Electrical rotation 356° ±2°; continuous mechanical rotation. Up to 8 taps can be added during manufacture with each tap welded to a single turn of resistance wire—*Electromath Corp., 190 Henry St., Stamford, Conn.*

For more information circle **299** on inquiry card.

CAPACITORS

VERNIER CAPACITOR



New "V-Cap," specifically designed for computer applications, is recommended also for any application where a 0.1 to 1-mfd capacitor must be adjusted to an accuracy of better than 0.05%. Reported stabilities better than 0.01%; almost undetectable dielectric absorption; insulation resistance 10^{14} ohms; dissipation factor 0.0005. Adjustment range is 1% on either side of nominal capacitance.—*Balco Research Labs., Inc., 49-53 Edison Pl., Newark 2, N. J.*

For more information circle **300** on inquiry card.

STAND-OFF CAPACITORS

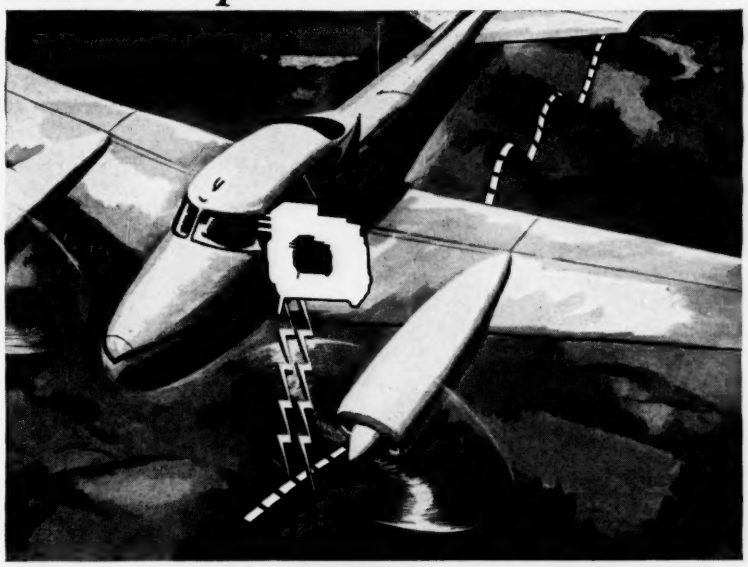
New "Series X2122 stand-off capacitors with ceramic dielectric, available in a group of values, are general RF by-pass capacitors for use in high-quality electronic equipment. Encapsulating resin provides exceptional rigidity and durability under extreme shock, vibration and humidity. Unique design feature minimizes breakage of dielectric ceramic under flexing of chassis and mounting surfaces. Over-all height when mounted is less than ⅜".—*Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.*

For more information circle **301** on inquiry card.

PAPER TUBULAR CAPACITORS

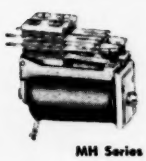
New line of molded PVZ capacitors meets need for a moderately-priced high-quality 125C paper tubular capacitor. Units operate from −55°C to 125°C without voltage derating, are for applications in computers, missiles, other high-grade military and commercial equipment; are available in 100-v to 400-v ratings; from 0.00047 to 0.022 uf in 400-v range

Potter & Brumfield *engineering is in this picture*



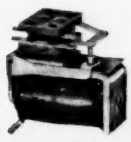
Which P&B relay did Television Associates specify

FOR THEIR AIRBORNE COMPUTER?



MH Series

MB Series



MC Series

Surveys for pipe lines, electric transmission routes and microwave paths are now made from the air, by radar. Television Associates of Indiana, Inc. developed this speedy new technique—and the equipment—which provides clients with detailed profiles of the terrain to be crossed.

Part of the equipment, an intricate airborne computer, requires relays that are fast-acting, light weight, versatile. They must have high shock and vibration resistance and remain operative in temperatures ranging from −45° C to +85° C.

Modified MH relays by P&B were specified. These miniature relays meet all Television Associates' requirements and provide high reliability in a mighty small package. Challenging relay problems are solved daily at **P&B.** Twenty-five years of creative engineering are behind every P&B relay. Write today for our new catalog.

ENGINEERING DATA

SERIES: MH Miniature Telephone.

CONTACTS: Up to 18 springs, maximum 9 in each stack, forms A, B, C, D, E, X and Y. AC relays are limited to a maximum of 2 poles. Various contact material available.

VOLTAGE RANGE: DC - .05 to 110 V.— AC - 6 to 230 V. 60 cycle.

COIL RESISTANCE: 22,000 ohms maximum.

TEMPERATURE RANGE: High temperature range (DC) −55° C. to +135° C. Standard DC −55° C. to +85° C. Standard AC −45° C. to +40° C. Other temperature ranges available to specification.

TERMINALS: Standard pierced solder lug holes will take (2) No. 18 hook-up wires. Adaptable for printed circuits.

ENCLOSURES: Dust cover plus wide range of hermetically sealed covers and types of terminations.

DIMENSIONS: 1-9/16" L. x 25/32" W. x 1-3/8" H. (4c Relay).

P&B RELAYS AVAILABLE AT MORE THAN 500 DISTRIBUTORS IN ALL PRINCIPAL CITIES

Potter & Brumfield, inc.

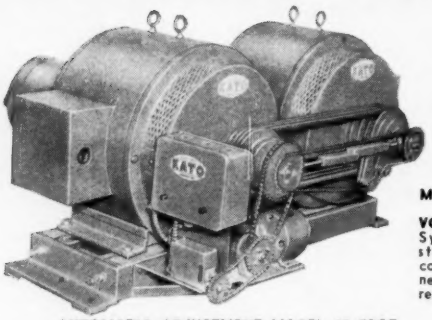
PRINCETON, INDIANA *Subsidiary of* AMERICAN MACHINE & FOUNDRY COMPANY

Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

For more information circle **105** on inquiry card.

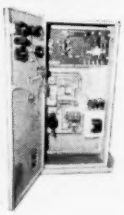
For Better Bench Mock-Up Tests

KATO VARIABLE FREQUENCY MOTOR GENERATOR SETS



REMOTE CONTROL
Remote control frequency adjustment varies speed from 1080 to 1320 RPM, thus varying frequency. Bench mock up test station may be located anywhere.

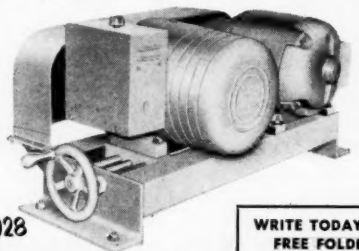
MAGNETIC AMPLIFIER AUTOMATIC VOLTAGE REGULATOR
Synchronous motor starter and generator controls, including magnetic amplifier voltage regulator in cabinet.



AUTOMATIC ADJUSTMENT MODEL 45 EPOT
Fully automatic variable frequency motor generator set adjusts 360 to 400 CPS. Generator mounted controls include reset buttons, Cutler-Hammer Limit Switch. Motor and generator remain stationary. Vari-drive pulley adjustment controlled by small motor.

A. C. GENERATORS • 60 CYCLE FROM 350 WATTS TO 500 KVA.

MANUAL ADJUSTMENT MODEL 28XA08
Easily adjusted by simple hand wheel controlling variable pitch pulley V-belt arrangement. This motor generator set gives 45 to 60 cps output. Unit holds speed accurately. Frequency meter on generator panel indicates output. Single phase generator speed varies from 1350 to 1950 rpm.



Builders of Fine Electrical Machinery Since 1928

KATO *Engineering Company* 1490 FIRST AVENUE MANKATO, MINN.

WRITE TODAY FOR FREE FOLDER! IT'S NEW!

For more information circle **106** on inquiry card.

Now you can

solder as easy as you write!

—with

HEXACON

INSTRUMENT SOLDERING IRONS

—for fast soldering and long life on constant duty

Because of new efficient design, these tiny tips out-perform irons with larger tips and higher wattages. HEXACON offers a new standard in soldering iron efficiency for every conceivable need in the soldering of miniature assemblies.

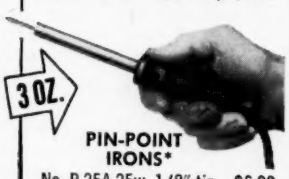
Send for new circular No. 127 giving more details and comparative competitive performance data.

2 OZ.

SUPER-PENCIL IRONS*
No. 25S 25w. 1/8" tip $6.00
No. 26S 30w. 3/16" tip $6.00

3 OZ.

BANTAMWEIGHT HATCHET IRONS*
No. 25H 25w. 1/8" tip $6.50
No. 26H 30w. 3/16" tip $6.50



3 OZ.

PIN-POINT IRONS*
No. P-25A 25w. 1/8" tip $6.00
No. P-26 30w. 3/16" tip $6.00

*Also available in higher wattages

INDUSTRY'S No. 1 HEXACON SOLDERING IRON

HEXACON ELECTRIC COMPANY
506 West Clay Ave., Roselle Park, New Jersey

For more information circle **107** on inquiry card.

NEW INSTRUMENTS

and from 0.00047 to 0.15 uf at 100 v. Nine different sizes accommodate the various ratings.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **302** on inquiry card.

ELECTRONIC COMPONENTS

TWIN TRIODE

New "Type CK 6832," designed especially for dc amplifier and computer applications, is a subminiature

twin triode with unusually low microphonics and grid current. It is controlled for balance between the two sections including stability with time, shock and variation in heater voltage. Electrically, it is similar to miniature "CK5755."—*Raytheon Mfg. Co., 55 Chapel St., Newton 58, Mass.*

For more informatino circle **303** on inquiry card.

COINCIDENCE THYRATRON

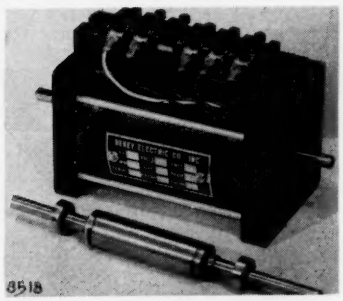
New "Type KP-80" coincidence thyratron (actual size illus.) utilizes new and unique principle of ion deflection; has three control grids and is designed for use where the coincidence of either two OR THREE events (signals received) causes some operation (tube conduction). For example, when it receives three simultaneous signals, it conducts, closing a relay, which might in turn cause a drill to be positioned. In circuits where coincidence functions are now accomplished with as many as fourteen components (performing merely double coincidence) use of "KP-80" will save time and space, will minimize cost, and will maximize equipment reliability.—*Kip Electronics Corp., Department R-1, Stamford, Conn.*

For more information circle **304** on inquiry card.

ELECTROMECHANICAL COMPONENTS

SERVOMOTORS

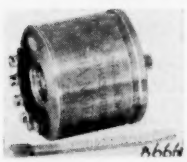
New "Models 216, 232 and 248" low-inertia servomotors, nominally rated at 10, 20 and 30 watts respectively, achieve extremely high acceleration by use of a small-diameter rotor, whence exceptionally high torque-to-inertia ratios. Other features are linear torque-speed characteristic,



high hp-to-weight ratio, and quiescent current cancellation.—*Bekey Electric Co., Inc.*, 1327 *S. Main St., Los Angeles* 15, *Calif.*

For more information circle **305** on inquiry card.

SIZE 10 SERVO



New "Type 10-5032-23" size 10 servo for use with a transistorized amplifier will not single-phase (1) with fixed phased energized and (2) with a tuning capacitor 250% in excess of value required to tune control phase to unity power factor connected across control phase. Characteristics include 115-v fixed phase 36-v control phase with 3 watts per phase stalled; 6500 rpm at no load and 0.26 oz-in at stall minimum; operating temperature range −65°C to 85°C. Available with gear train, brake and environmental conditions specified.—*John Oster Mfg. Co., Avionic Div., Racine, Wis.*

For more information circle **306** on inquiry card.

MOTOR-GEARHEAD CLUTCH

New 400-cps high-performance miniature motor-gearhead-clutch BuOrd Size 10 (0.938" dia.), max length 1¾", is designed to operate directly from either 115-v or 26-v line. Common aluminum housing minimizes alignment and assembly problems while use of aluminum makes possible a minimum weight and temperature rise Various gear ratios available without changing basic configuration. Gearing and loads protected by an integral slip clutch.—*Servomechanisms, Inc., Mechatrol Div.*, 625 *Main St., Westbury, N. Y.*

For more information circle **307** on inquiry card.

DC TO AC CONVERTERS

New 750-watt model has been added to maker's "Custom" line. Pole shoes and field ring are cast in a single unit, to eliminate electrical loss and simplify construction. Units are specially engineered for marine and in-

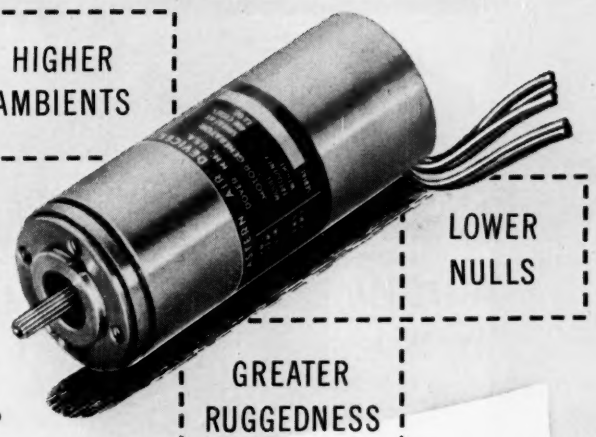
EAD announces an unusually precise

SERVOMOTOR-TACHOMETER GENERATOR

HIGHER AMBIENTS

LOWER NULLS

GREATER RUGGEDNESS



SIZE 11
SJ1HLX7
(Actual size)

for
INSTRUMENTATION
FIRE CONTROL
AUTOPILOTS
MISSILES
COMPUTERS

FEATURES:

Zero Speed Voltage (RMS)	8.0 mv in phase 15.0 mv quadrature 19.0 mv total
Max Ambient Temp.	150°C
Linearity	0.5% to 3600 rpm
Output Gradient Phase Shift	0.5V/1000 rpm (min.) ±10%

Servo motor meets Bu. Ord. MK-14 specifications.
Equipped with precision gearhead for lower backlash.
Rugged, one-piece assembly.

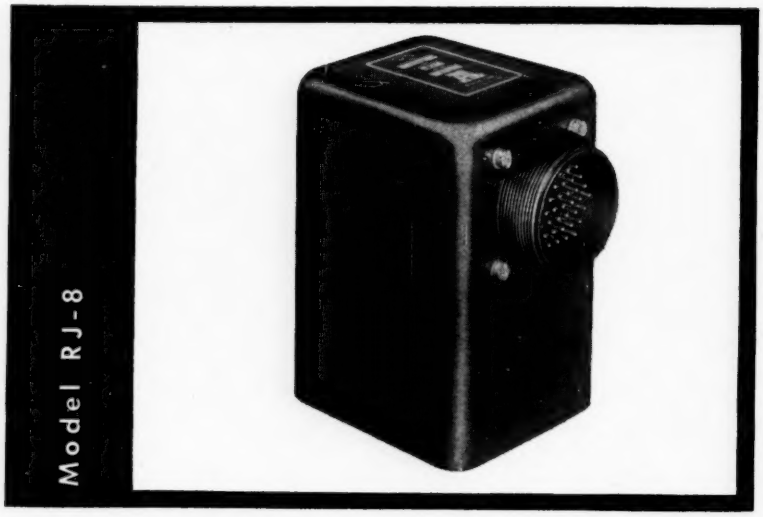
WRITE for complete detailed information

EASTERN AIR DEVICES, INC.
SOLVING SPECIAL PROBLEMS IS ROUTINE AT EAD
347 CENTRAL AVENUE • DOVER, NEW HAMPSHIRE

For more information circle **108** on inquiry card.

INTRODUCING A NEW
TECHNIQUE IN AIRBORNE
THERMOCOUPLE INSTRUMENTATION
WHICH OBSOLETES CRACKED
ICE AND THERMOS BOTTLES

ARNOUX
Thermocouple Reference Junction



ARNOUX "hot" reference junctions eliminate the need for obsolete, inaccurate ice baths or cold junction compensation, and require no attention prior to use.

Extremely rugged and compact, these units provide constant 250°F. temperature at the junction of thermocouple wires and copper leads. Regulated within 1.7°F., throughout MIL-E-5272A ambients.

Models are available for 24 volt d.c. or 115 volt, 60 or 400 cps. Choice of thermocouple materials. Sizes range from 2 to 12 channels.

Write for Bulletin 400.

ARNOUX... *foremost* in
TEMPERATURE MEASUREMENT EQUIPMENT...
... **TRANSDUCERS, ACCESSORIES AND CUSTOM ENGINEERED SYSTEMS.**

ARNOUX CORPORATION

11924 West Washington Blvd.
Los Angeles 66, California

Designers and Manufacturers of Precision Instrumentation

For more information circle **109** on inquiry card.

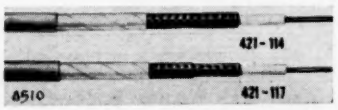
NEW INSTRUMENTS

dustrial service; are available for input voltages of 24, 28, 32, 48, 64, 72, 115 and 230 v ac and deliver clean 115-v 60-cps ac.—*Carter Motor Co.*, 2711 *W. George St., Chicago* 18, *Ill.*

For more information circle **308** on inquiry card.

NON-MAGNETIC TEFLON CABLES

Two new Teflon coaxial cables with non-magnetic conductors, similar in all other respects to RG-141/U and

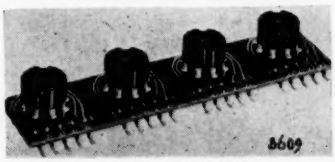


RG-142/U cables, are for use where both high temperature and non-magnetic qualities are desirable—*Amphenol Electronics Corp., Chicago* 50, *Ill.*

For more information circle **309** on inquiry card.

RIGHT-ANGLE SOCKET MOUNT

New multiple right angle socket mounting for use in conjunction with printed circuits can be applied also



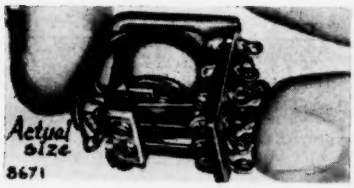
for mounting resistors and capacitors that have not previously been incorporated into circuit. It is an offshoot of single socket mounting introduced by maker. It can incorporate sockets of the same size or of varying sizes, and can be constructed to meet user specs.—*Cleveland Metal Specialties Co.*, 1783 *E. 21st St., Cleveland* 14, *Ohio.*

For more information circle **310** on inquiry card.

RELAYS

SUBMINIATURE RELAY

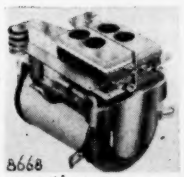
New "KM" subminiature 3-pole relay meets demand for miniaturization and multiplicity of action within a single relay. Contacts: Max 3p-dt, 3/32" dia silver, 2 amp 115 v 60 cps; coil resistance up to 6,700 ohms; one



watt power requirement; temperature range −45°C to 55°C; shock resistance 30*G* without mechanical damage. —*Potter & Brumfield, Inc., Princeton, Ind.*

For more information circle **311** on inquiry card.

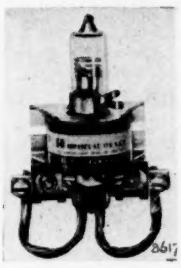
MINIATURE RELAY



New "Type 4-C" relay, for applications compelling minimal size but requiring maximal sensitivity, long life, and low power consumption, uses maker's standard "Type 4" contact spring assembly; offers many variations in contact arrangements and contact materials. Available coils include single or double wound, time delay slugs, and special windings for high temperature and/or high humidity.—*Phillips Control Corp., Joliet, Ill.*

For more information circle **312** on inquiry card.

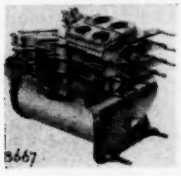
MERCURY RELAYS



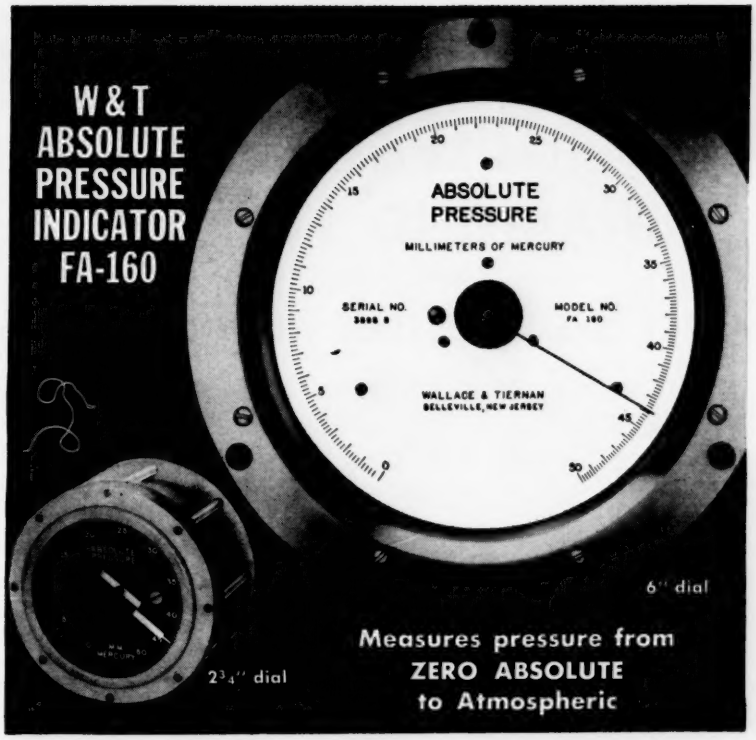
New "EML-1" (4000 watt) and "HDL-1" (6900 watt) normally-open mercury plunger relays are UL approved for tungsten lamp loads at 115 v 50/60 cps; are built to safely carry tungsten surge currents up to ten times steady state current without failure, flicker or sticking; provide stable contact resistance of about 0.001 ohm; are recommended for a maximum of 60 complete operations per minute. Moisture-resistant coils available in a number of stock voltages or custom-made to meet specs.—*Ebert Electronics Corp.*, 212-26 *Jamaica Ave., Queens Village* 28, N.Y.

For more information circle **313** on inquiry card.

RELAY WITH TERMINALS FOR PRINTED CIRCUITS



New "Type 8" relay has printed circuit terminals which are available with standard twin-contact springs (widely used for maximum reliability in switching circuits) or with single-contact springs or power-type con-



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0-800mm Hg. 390-800mm Hg.
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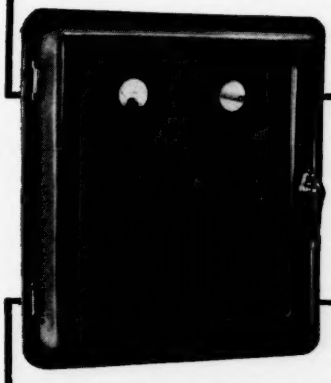

HOW TO DETECT 3 PARTS CHLORINE IN A MILLION PARTS AIR

New W&T Solvay Chlorine Detector*
detects as little as 3 p.p.m. chlorine in a continuous air-stream sample. Automatically sets off alarm at higher concentrations.
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*Manufactured under patent license from Solvay Process Div., Allied Chemical & Dye Corp.

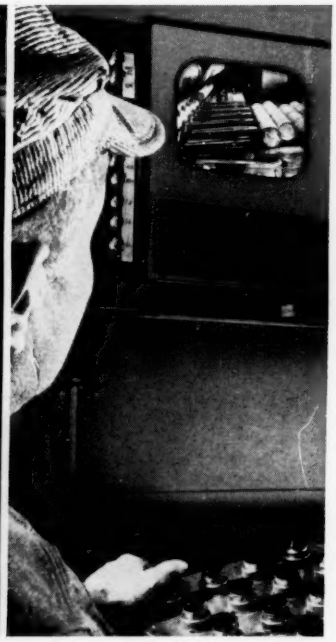
For more information circle **110** on inquiry card.

TIMKEN Company ORDERS 2 MORE DIAMOND ITV UNITS

(WIRED TELEVISION)

AFTER 3 SUCCESSFUL INSTALLATIONS

Picture of furnace interior on Diamond ITV viewing screen is watched by remote dispatcher. A flip of a switch and he SEES conditions in another furnace on same screen.

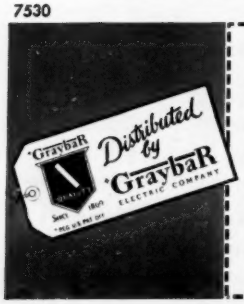


Operator at another control pulpit SEES a visually inaccessible billet loading area for a pusher type furnace.

The Timken Roller Bearing Company made its first application of Diamond Industrial TV in August 1951 for remote observation of the interior of a tube-cooling furnace. Since that time two additional installations have been made to watch (1) the inside of another furnace and (2) the remote handling of billets by a crane. The success of these has resulted in a recent order for two more sets of Diamond ITV.

You, too, probably can use Diamond ITV to substantial advantage. Call your Graybar Distributor or use the coupon below.

7530



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For more information circle **111** on inquiry card.

tacts for switching large current loads. For extremely low-level loads, gold alloy or other special contact materials are available. Terminals are tinned for ease of soldering and ready insertion into circuit board, are ribbed for added strength, fully supporting relay and eliminating mounting screws.—*Phillips Control Corp., Joliet, Ill.*

For more information circle **314** on inquiry card.

SWITCHES

SELECTOR SWITCH

New fifty-channel selector switch is mainly designed for strain gages, thermocouples, multichannel testing,

etc. Change in contact resistance of any switch point does not exceed 0.48 milliohm and averages 0.08 milliohm. (This corresponds to less than 1 microinch per inch strain for a 120-ohm "SR-4" strain gage.) Alphlex insulation used throughout. Extremely low loss switching is assured. Common terminal strip mounted below binding post facilitates quick hookup. Engraving on both front and back panels for permanence.—*Good Electronic Corp., P.O. Box 406, Natick, Mass.*

For more information circle **315** on inquiry card.

ENCLOSED LIMIT SWITCH

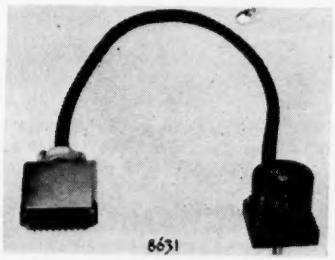
New "Type 30" sealed precision limit switch features versatility: sixteen types of switches from a few

interchangeable components. Plunger actuator has a 0.002" differential and ½" overtravel. Roller arm actuator has a micrometer screw adjustment which eliminates trial and error method and offers an unlimited number of trip positions. Roller plunger actuator is adjustable through 360°.—*Licon Switch & Control Div., Illinois Tool Works, 2501 N. Keeler Ave., Chicago 39, Ill.*

For more information circle **316** on inquiry card.

40-CHANNEL HIGH-SPEED SAMPLING SWITCH

New high-speed sampling switches feature unusual economy, plug-in connections and high performance, up to



40 shorting channels or 20 non-shorting channels; maker's constant-force brushes for extended service-free life. —*General Devices, Inc., Princeton, N. J.*

For more information circle **317** on inquiry card.

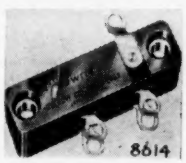
NYLON-MOLDED SWITCH FOR RESISTANCE DECADES

New nylon-molded switch for maker's Wheatstone bridge and decade boxes is superior both electrically and mechanically to previous construction, features exceptionally low resistance contacts (less than 0.003 ohm) provided by quadruple wiping springs of phosphor bronze riding on silver-plated brass segments.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.*

For more information circle **318** on inquiry card.

MULTIPOLE SWITCHES

New system of precision "stacking" of Class 1 "TyniSwitches" makes it possible to obtain a single switch actuating two or more completely independent circuits. Space saving is one advantage. Each individual switch action can be dt, st-no, or st-nc. Maximum pin movement from first contact actuation of all contacts is 0.015". "Type B" switches are UL listed at 15 amps 125 or 250 vac, ½ hp, 125 or 250 vac; "Type D" switches are UL listed at 10 amps 125 or 250 vac.—*TyniSwitch Dept., Detroit Controls Corp., 800 Union Ave., Bridgeport, Conn.*



For more information circle **319** on inquiry card.

HINGED LEVER SWITCH

New hinged lever actuator "TyniSwitch" features ease of removal or assembly of lever. This makes it possible to use standard parts and add

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The following are typical of components and systems available from Potter for satisfying your digital requirements:

Digital Data-handling Equipment

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- ☐ Record-Playback Amplifiers
- ☐ Record-Playback Head Assemblies
- ☐ Magnistors
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- ☐ Predetermined Electronic Counters
- ☐ Counter Chronographs
- ☐ Frequency-Time Counters
- ☐ Totalizing Counters and Scalers
- ☐ Plug-In Counter Decades
- ☐ Photoelectric Count Detectors
- ☐ Photoelectric Screen Detectors
- ☐ Translators and Printers

Special Systems

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- ☐ Militarized Counters and Timers
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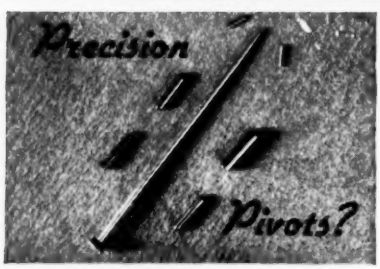

The "spike" in the center is a common pin. The others are VK precision pivots.

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For more information circle **115** on inquiry card.

NEW INSTRUMENTS

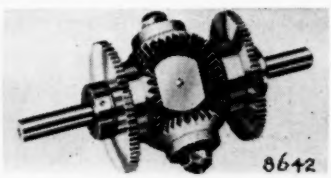
secondary operations to lever to meet special application requirements. Pretravel max 0.250"; overtravel min 0.200"; movement differential 0.020" to 0.080"; operating force max "Type A" 18 grams, "Type B" 10 grams; release force min "Type A" 9 grams, "Type B" 4 grams. UL and CSA rating 15 amp, 125 and 250 vac.—*Tyni-Switch Dept., Detroit Controls Corp., 800 Union Ave., Bridgeport, Conn.*

For more information circle **320** on inquiry card.

MECHANICAL COMPONENTS

MINIATURE DIFFERENTIALS

New miniature differentials, said to be characterized by minimum backlash, high accuracy and low break-

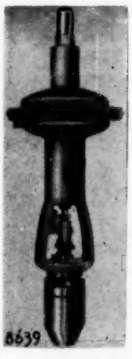


away torque, feature bevel gears of Gleason-Coniflex type; preloaded ball bearings; and gears cut to AGMA Precision Class 2. Three stock models have ¼", $\frac{3}{16}$" and ⅛" shafts; max recommended torques of 150, 100 and 90 oz-in; and max recommended speeds of 1800, 1800 and 1400 rpm.—*Helipot Corp., Newport Beach, Calif.*

For more information circle **321** on inquiry card.

VALVES

TUNGSTEN CARBIDE PLUGS

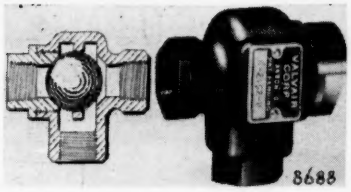


New "Microflo Valve Tungsten Carbide Plugs," in twenty-five interchangeable sizes, provide predictable flow control in a formerly "impossible" low flow range, enabling pilot plants and laboratories to scale down their process to more manageable proportions. Ten new sizes include C_V (max.) = 0.00063 (#16) to C_V (max.) = 0.000010 (#25). Minimum flow is $\frac{1}{50}$ of the max C_V. Nominal "Microflow Valve" body sizes are ½", ¾" and 1".—*Hammel-Dahl Co., 175 Post Road, Providence 5, R. I.*

For more information circle **322** on inquiry card.

DIRECTIONAL VALVE

New directional valve affords instant switchover from automatic to manual control of diaphragm-oper-



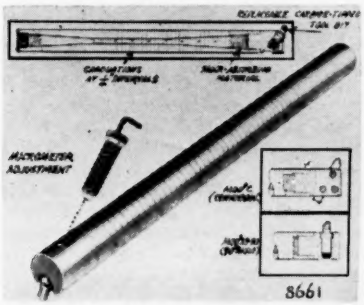
ated valves, cylinders, etc.; can be used also to prevent intermixing of supply when two gases or liquids are being delivered alternately. Principle: when pressure is applied to one port, ball shifts to, and seals, opposite port. Suitable for use with all fluids compatible with Hycar and bronze. Available with ¼" and ⅜" ports.—*Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.*

For more information circle **323** on inquiry card.

SHOP EQUIPMENT

BORING BAR

New vibration-proof and chatterless boring bar, equipped with a micrometer adjustment to adjust cut-

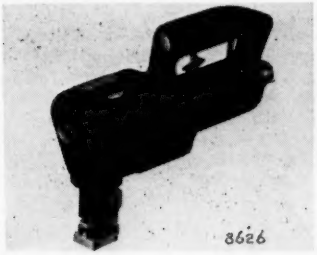


ting tools in 1000ths, is constructed of shock-absorbent material and special alloy heat-treated steel; is offered with cutting tool at 53° angle or at 90° angle, and micrometer adjustment tool bit. (Also available with conventional non-adjustable tool bit.) —*Modern Mfg. Co., Inc., Edgemont & Clementine Sts., Philadelphia, Pa.*

For more information circle **324** on inquiry card.

PORTABLE NIBBLER

New portable air-operated metal cutting nibbler cuts up to 55" per minute through 10-gage stainless steel without distortion on either side of cut, leaving edge ready for fabricating. Short turning radius (6") allows



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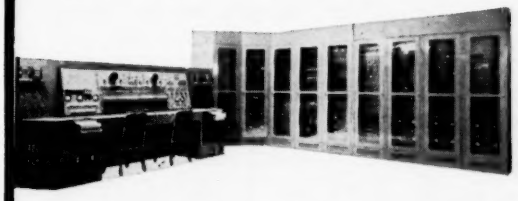

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For more information circle **116** on inquiry card.

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210 Mc

20db GAIN

- Extended low frequency response to 1000 cps
- High frequency response to 210 Mc with linear phase shift and rise time less than .0026 μ sec
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For more information circle **119** on inquiry card.

NEW INSTRUMENTS

for intricate patterns and special openings. Tool weighs 13 lb, is 13" long.—*Fenway Machine Co., Edgemont and Clementine Sts., Philadelphia 34, Pa.*

For more information circle **325** on inquiry card.

INSPECTION & GAGING

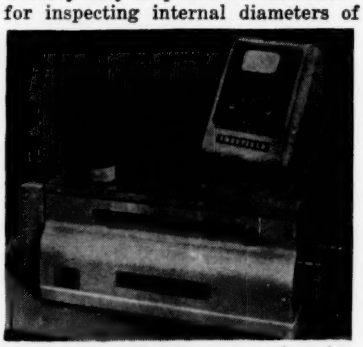
BORESCOPE

New needle-like "TG-1 Borescopes," for examination of diesel injection nozzles and other small tubes and cavities, have optical systems with lenses in some cases smaller than a pin head, yet image quality is more than adequate for detection of flaws, dirt, erosion, etc. Three models, for bores from 0.160" to 0.250", 0.200" to 0.312", and 0.240" to 0.375". Optical tube can be rotated with respect to handle, and adjusted inward or outward therein to obtain optimal reflection of light from walls under observation. Each borescope is supplied with four tubes, affording vision (1) directly forward, (2) obliquely forward, (3) at right angles to bore, (4) obliquely backward.—*Kollmorgen Optical Corp., 347 King St., Northampton, Mass.*

For more information circle **326** on inquiry card.

INTERNAL MEASURING INSTRUMENT

New "Model N-7 Internalchek" is a heavy-duty shop and lab instrument for inspecting internal diameters of



ring gages and other parts for size, taper, bellmouth and out-of-roundness. Standard capacity is 0.370" to 12" with vertical capacity to 1½". Instrument is available with dual electronic amplification of 1000/2000 to 1, 2500/5000 to 1, or 5000/10,000 to 1.—*The Sheffield Corp., Dayton 1, Ohio.*

For more information circle **327** on inquiry card.

MISCELLANEOUS

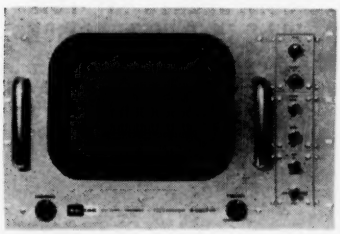
NEON GLOW LAMPS

New glow-lamp indicators, pilot lights and test lamps generate practically no heat, offer practically flat volt-ampere characteristics; withstand shock and vibration; come with bayonet or screw base; are available in standard types or custom types to users' specs.—*Laine Electronics, Inc.*, 91 *Industrial Ave., Little Ferry, N. J.*

For more information circle **328** on inquiry card.

CLOSED-CIRCUIT TV MONITOR

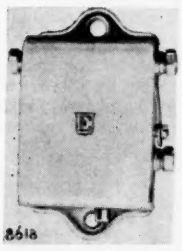
New "Model ARM-14" 14" video monitor provides remote viewing of video information from maker's in-



dustrial or broadcast TV camera chains; can be positioned up to 1000 ft from camera control unit (farther if line amplifiers are used). Available in cabinet or 19" rack mountable chassis.—*Kay Lab*, 5725 *Kearny Villa Road, San Diego* 11, *Calif.*

For more information circle **329** on inquiry card.

ALARM RESET DROP



New "No. 26" constant-ringing drop, for alarm systems where immediate attention is required and where reset feature is needed for restoration of alarm system, is particularly well suited for many types of industrial control alarms, fire alarm systems and annunciators. It operates in low-voltage circuit that can be supervised by liquid level, temperature, speed or pressure switch, relay, etc. Supplied through electrical distributors for 6-8 volt d-c or 8-12 volt a-c circuits.—*Edwards Co., Inc.*, 90 *Connecticut Ave., Norwalk, Conn.*

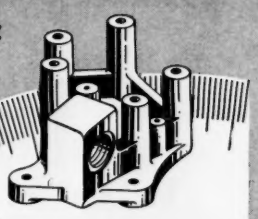
For more information circle **330** on inquiry card.

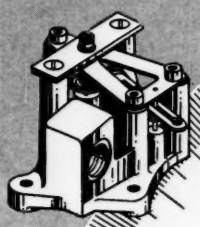
DIRECT-DRIVE FAN MOTORS

New "Models S-60-D, S-13-H and S-16-H" reduced-depth direct-drive fan motors, for application in remote-condenser central air conditioning sys-

HEISE GAUGES

The Standard of the World

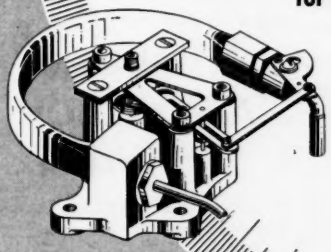


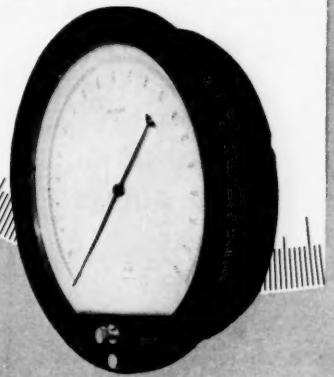


Integration In Design

The inherent stability of the Heise Gauge movement and the elimination of significant hysteresis effect in the integrally mounted Bourdon Tube give the Heise Gauge its ability to indicate faithfully the most minute pressure variations. The scientific design of the Heise Bourdon Tube section and its weldless construction from carefully selected and heat treated metals is an exclusive Heise feature.

Custom designed to meet your specific needs, this gauge will register precisely for liquids, gases or mercury. Convenient adjustment of the dial may be used to compensate for barometric changes.





Pressure Ranges
15 to 20,000 P.S.I.

DIAL SIZES
8½" – 12" – 16"

PRICES
from $151.60

DELIVERY
within 30 days

Catalog on Request

HEISE BOURDON TUBE COMPANY, INC.
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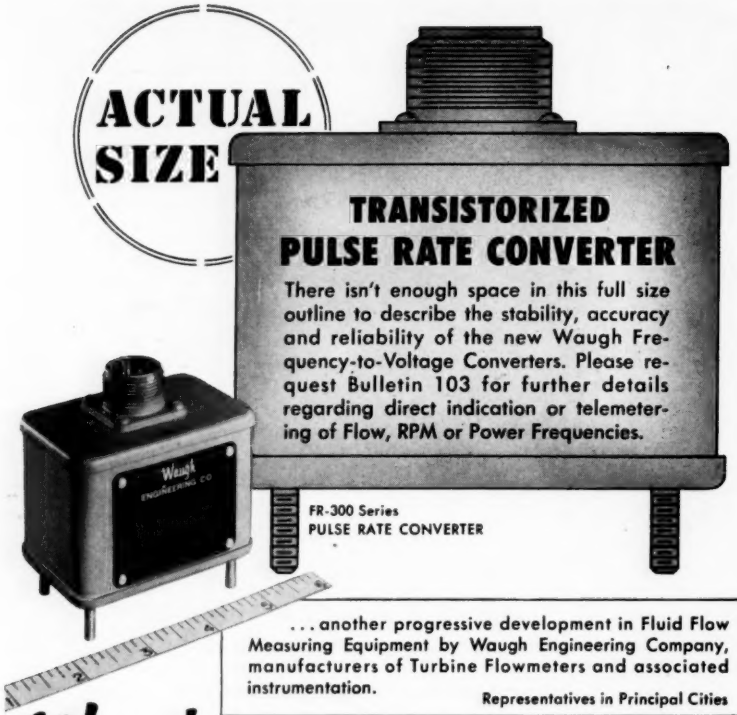
For more information circle **120** on inquiry card.


ACTUAL SIZE
TRANSISTORIZED
PULSE RATE CONVERTER
There isn't enough space in this full size outline to describe the stability, accuracy and reliability of the new Waugh Frequency-to-Voltage Converters. Please request Bulletin 103 for further details regarding direct indication or telemetering of Flow, RPM or Power Frequencies.
FR-300 Series
PULSE RATE CONVERTER

. . . another progressive development in Fluid Flow Measuring Equipment by Waugh Engineering Company, manufacturers of Turbine Flowmeters and associated instrumentation.

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For more information circle **121** on inquiry card.

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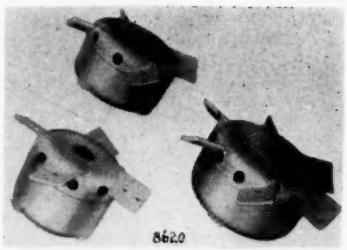
For more information circle **122** on inquiry card.

NEW INSTRUMENTS

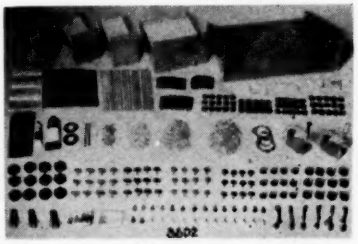


tems, are rated 950, 775 and 625 rpm respectively; operate on 230 v; feature quiet, vibration-free performance; are suitable for vertical or horizontal operation, come complete with thermal protective device, central lubrication system, etc. Hp ratings 1/12, 1/8 and 1/3 respectively.—*Electric Motors and Specialties, Inc.*, 100 *King Street, Garrett, Indiana.*

For more information circle **331** on inquiry card.

COMPONENTS KIT FOR PLUG-IN CONSTRUCTION

New "Basic Chassis and Terminal Card Assortment Alden Kit No. 37" minimizes layout and construction

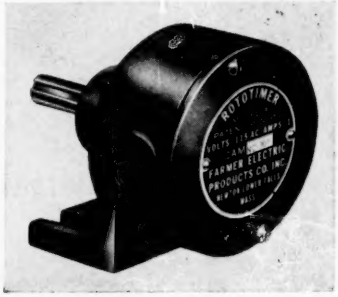


time of mounting and packaging electronic circuitry by providing engineer with flexible series of basic components necessary for mounting, packaging, housing and connecting his circuitry. It comes with Unit Planning Sheets enabling designer to plan all functional circuit units, component layout and housing sizes on the drawing board in one step.—*Alden Products Co.*, 117 *N. Main St., Brockton* 64, *Mass.*

For more information circle **332** on inquiry card.

SYNCHRONOUS CONTACTOR

New "Model 3 Rototimer" provides precise coordination of shaft position with electric circuit for punch press

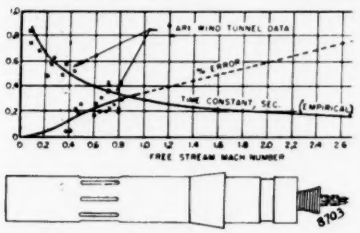


control, magnetic counter actuation, register control, etc., especially where operate point is carefully set and infrequently changed. Contacts are rated 1 amp non-inductive at 125 vac. Four types of interchangeable cams are available to vary switching functions.—*Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.*

For more information circle **333** on inquiry card.

STAGNATION-TEMPERATURE PROBES

New "T-1305" Total Temperature Probe is available with resistance or thermocouple elements. Resistance

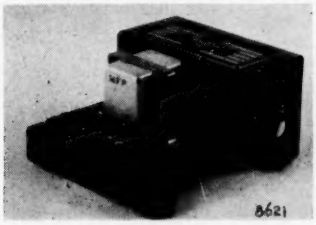


elements can be either metallic (ranges up to 1000°F) or thermistor. Thermocouple elements are available in ranges to 2800°F and usually show a faster response than resistance elements. New units employ double stagnation principle; are said to have high recovery, negligible radiation and conduction errors, rapid response to temperature changes, and complete insensitivity to 20° angle of attack.—*Aero Research Instrument Co., 315 No. Aberdeen St., Chicago 7, Ill.*

For more information circle **334** on inquiry card.

VOLTAGE & FREQUENCY MONITOR

New "Over/under Voltage/frequency Monitor" incorporates maker's "Regohm" regulator. Typical use: to



actuate an aural or visual warning signal when line is 5% off nominal voltage or frequency and disconnect or turn off equipment at 10% limit. "Percent Off" points are precisely adjustable, and monitoring functions of any degree of compexity can be performed.—*Electric Regulator Corp., Norwalk, Conn.*

For more information circle **335** on inquiry card.

ELLIPSE TEMPLATES

New "No. 400 Large Ellipse Set" consists of four templates, 20°, 30°, 45° and 60° projection; are available

PROBLEM:

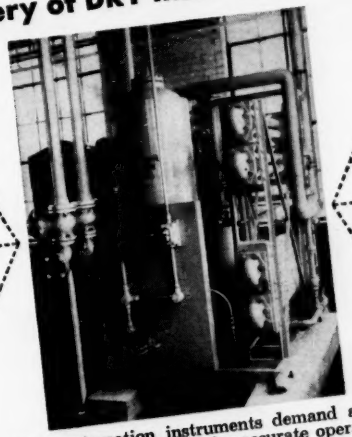
Moisture in instrument air lines causing control trouble, corrosion and freeze-ups in cold weather!

ASSIGNMENT: Find a low-cost, dependable means of getting DRY air!

SOLUTION:

Pritchard HYDRYER®

Unmatched for Continuous Delivery of DRY Instrument Air!



Precision automation instruments demand a constant source of extremely dry air for accurate operation. The Pritchard HYDRYER has proved its ability to deliver air that is free from damaging moisture. Only in a Pritchard HYDRYER do you get all of these features:

- NO WASTE — 100% of all air or gas entering the HYDRYER is dried without loss.
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- LONGER ADSORBENT LIFE.
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Kansas City, Missouri

For more information circle **123** on inquiry card.

STEREO— MICROSCOPE

CARL ZEISS

With novel rapid change of magnification from 6x to 160x with wide-angle oculars.

Large working distance from 3¾-in., with diameter of object field up to 32mm. Beyond 80x magnification, the working distance is 1⅝-inch.

Uniform sharpness over the entire field of view. Erect, non-reversed image. Outstanding plasticity; easy on the eyes even during prolonged observation.

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Guaranteed Uninterrupted Repair Service

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For more information circle **124** on inquiry card.

COMMUNICATIONS SYSTEMS ENGINEERS

The expanding scope of advanced communications projects has created several unique positions in fields related to VHF, UHF, microwave transmission and reception, forward scatter and single sideband applications at Hoffman. Electronics engineers with appropriate backgrounds will find these new assignments professionally stimulating and financially rewarding. Please address Vice President of Engineering:

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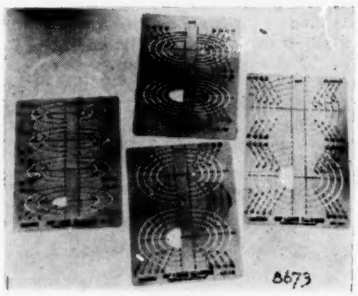
A SUBSIDIARY OF HOFFMAN ELECTRONICS CORP.
3761 South Hill St., Los Angeles 7, Calif.
Telephone: RIchmond 9-4831.

NEW INSTRUMENTS

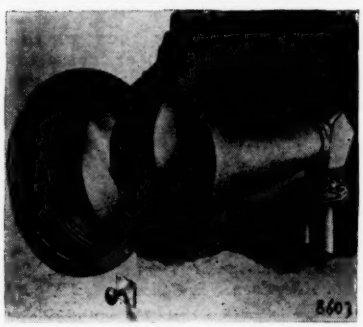


individually (Nos. 420, 430, 445 and 460) or as a set. Each template has a range of 2" to 6" major diameter, in increments of ⅛".—*Rapidesign, Inc., Box* 592, *Glendale, Calif.*

For more information circle **336** on inquiry card.

FURNACE PERISCOPE

New remote viewer solves problem of protecting operating personnel during the process of ingot production in



consumable arc furnaces; permits safe observation, through optical means, of travel of electrode; fits over furnace viewing port so that operator can stand safe outside a concrete barrier and study image of the electrode on an 8" ground glass screen through a safety glass window.—*Special Products Group, American Optical Co., Instrument Div., Buffalo* 15, *N. Y.*

For more information circle **337** on inquiry card.

PACKAGE INSPECTOR

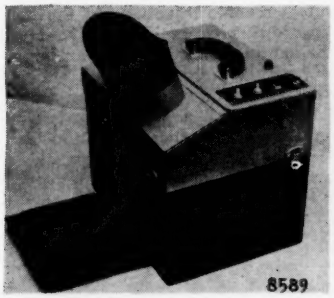
New Package Inspector utilizes high-frequency current passing through entire package. All materials respond to this current in proportion to their own electrical properties, as well as to volume of materials present. Thus, new device checks for weight, volume, presence or absence of cap or attachment, etc. It is pos-

sible also to single out certain materials inside a complicated package, and determine if they are present in wanted quantity, ignoring other materials in the package. Note: metal containers closed on all sides cannot be checked.—*Photobell Sales Corp., 43 Vesey St., New York 7, N. Y.*

For more information circle **338** on inquiry card.

ULTRAVIOLET INSPECTOR

New "Mineralab" fluorescence analysis cabinet for rapid identification under uv radiation is a self-

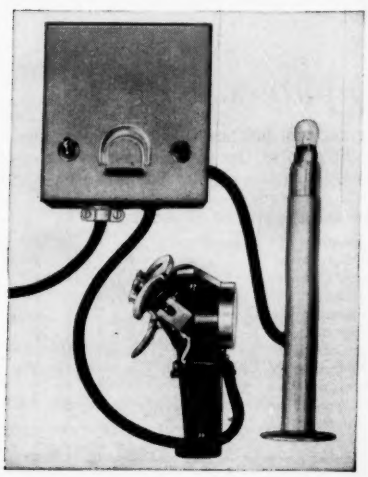


contained unit for field or lab analysis; contains both short- and long-wave uv lamps as well as white light for comparison. Doors on side allow specimens to be slipped into cabinet's "darkroom" A microscope can be mounted on front platform.—*Ultra-Violet Products Inc., 5114 Walnut Grove Ave., San Gabriel, Calif.*

For more information circle **339** on inquiry card.

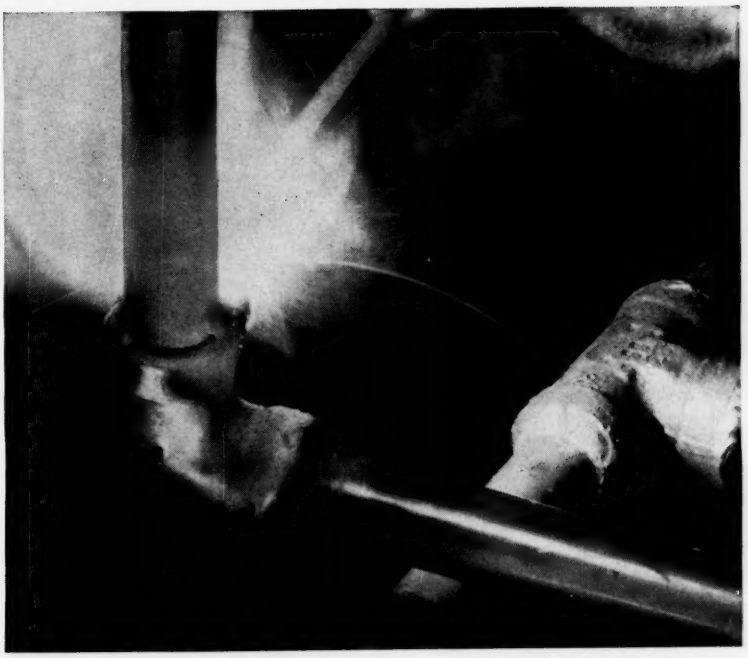
TENSION INDICATOR

New "Saxl Tension Meter" causes a novel electrical contacting device to call attendant by flashing a light



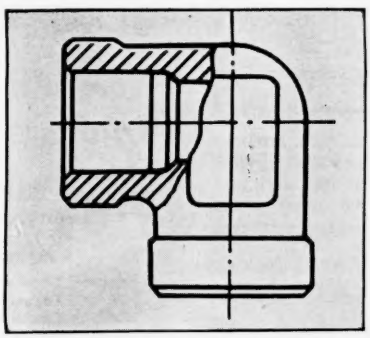
when tension goes above or below pre-set limits. Illustration shows tension annunciator attached to new "Saxl Tension Meter." Setting screws can be adjusted so that lever makes contact at any desired tension.—*Tensitron, Inc., Harvard, Mass.*

For more information circle **340** on inquiry card.

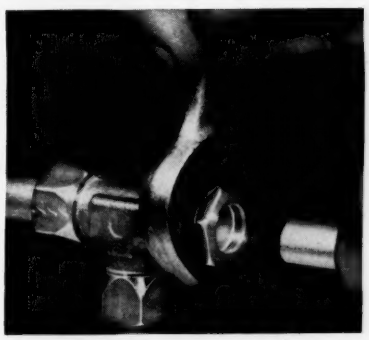


Simply insert tube, then weld! No wonder Parker Weld-lok *tube* fittings are so easy to use . . . by anyone, anywhere. You don't need special gripping fixtures. A tapered socket aligns and holds the tube. The permanently welded joint is unaffected by vibration, shock, or thermal distortion. Especially good under extreme temperature or corrosion conditions.

Use Parker Weld-lok fittings for tubing ¼ through 2" O.D.



Cutaway view of Weld-lok *tube* fitting shows detail of the simple design. All commonly used connectors and body shapes are offered in steel and stainless steel. Send for Catalog 4370 listing shapes, sizes.



Intru-lok fittings are easy to use for copper instrumentation lines. Just insert the tube, then tighten the nut with a regular wrench . . . for a leakproof vibration-proof joint. Also used with plastic tubing. Send for Catalog 4324.

TUBE AND HOSE FITTINGS DIVISION
Section 424-K
The Parker Appliance Company, 17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid system components

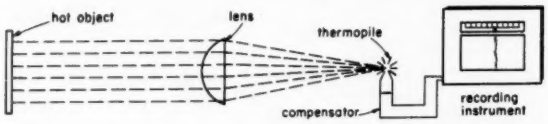
For more information circle **125** on inquiry card.

INSTRUMENTS and AUTOMATION Briefs

For this literature circle number on inquiry card.

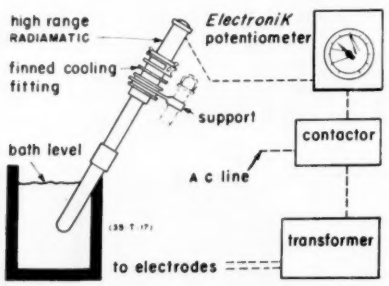
Radiation Pyrometry

A heated object emits radiant energy in the form of heat and light rays. The lens of the radiation detector focuses these rays upon the detector's thermopile. The thermopile —an assembly of very small thermocouples wired in series to multiply the emf—converts the radiant energy into an



emf which is translated into a temperature reading by a millivoltmeter or potentiometer type of instrument. Charts and scales are not evenly graduated because the emf generated by the thermopile increases exponentially as a power of the temperature of the hot object . . . .

Brown Radiamatic units are calibrated under black body conditions. A black body is defined as one which for a given temperature radiates the maximum amount of heat energy. It is usually illustrated by considering a hol-

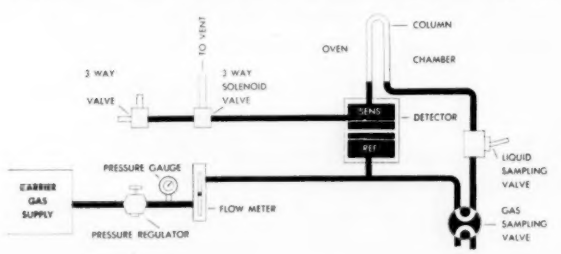


low enclosure wherein all objects are at a uniform temperature. If a radiation pyrometer is sighted upon the inner surface of such an enclosure, it will receive the maximum amount of radiant energy, for the existing temperature. (*From new* 28-*page Catalog* C93-1, *Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Aves., Phila.* 44, *Pa.*

For this literature circle **401** on inquiry card.

Vapor Fractometer

The illustration shows the instrument schematic of the Vapor Fractometer. Helium, the carrier gas, is supplied from an external gas bottle. The carrier gas passes through a flow meter and then by the reference side of the detector before the point of sample injection. At the point where the sample is introduced a small flash heater is provided to vaporize the sample immediately. Carrier gas and sample vapor then pass through the column and into the sensing side of the detector. The reference and sensing sides of a thermal conductivity cell are incorporated into a balanced bridge circuit. When a thermal conductivity difference occurs between the sides of the detector, the resulting bridge unbalance provides a voltage which drives a standard strip chart recorder . . . . (*From new* 16-*page bulletin, The Perkin-Elmer Corp., Norwalk, Conn.*)



For this literature circle **402** on inquiry card.

Digital Voltmeters

The digital voltmeter operates essentially as a self-balancing digital potentiometer with a high input impedance. In those instruments having automatic decimal positioning, the unknown input voltage is applied to a voltage divider network on the range unit. This unit selects a voltage from the divider network according to the range of operation and transmits this voltage to one side of the chopper, simultaneously closing the corresponding lamp circuit to illuminate the correct decimal point in the readout display. When range switching is not required, the unknown input voltage is applied directly to the chopper . . . (*From new* 28-*page Catalog* 356, *Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif.*)

For this literature circle **403** on inquiry card.

Analog Computers

Frequently, a customer will ask us to recommend an assortment of GAP/R modules for the construction of a computer to solve undefined problems. This is in contrast to

GENERALIZED ASSORTMENTS OF K3 MODULES

Model	Computing Equipment	Assortment	G	A	P	R
CS	Central Signal Component		1	1	1	1
CR	Central Response Component		1	1	1	1
K3-A	Adding Component		2	4	6	9
K3-B	Bounding Component		•	1	2	3
K3-C	Coefficient Component		4	8	12	18
K3-D	Differentiating Component		•	1	1	1
K3-E	Augmenting Differentiator		•	•	1	2
K3-H	Backlash Component		•	1	1	2
K3-J	Integrating Component		2	4	6	9
K3-K	Augmenting Integrator		•	•	1	2
K3-L	Unit-lag Component		1	2	3	4
K3-S	Squaring Component		•	1	•	1
K3-T	Square Rooting Component		•	•	•	1

the customer who has groups of problems with well defined similarities. For the latter, a specific assortment of units can be listed. For the former, a generalized assortment must be assembled . . . (*From "The Lightning Empiricist," Issue. No.* 5, *Geo. A. Philbrick Researches, Inc.,* 230 *Congress St., Boston* 10, *Mass.*)

For this literature circle **404** on inquiry card.

CRESCENT

IMPROVED CABLED TUBING

for use with INSTRUMENTS and PROCESS CONTROL EQUIPMENT

12, 1/4" O.D. Tubes Type CA

Tubes furnished in

- ***Copper***
- ***Aluminum***
- ***Steel***
- ***Polyethelene***

Also Special Construction for Underground Runs

Substantial savings on installed cost on moderate to long runs with complete dependability is achieved through the use of CRESCENT ARMORED MULTITUBE*. It is furnished in continuous lengths up to 1000 feet, thus saving waste and short ends. Corrosion resistant constructions are also available.

CRESCENT ARMORED MULTITUBE*

Carries Air, Gas or Fluid

CRESCENT ARMORED MULTITUBE* is a group of from 2 to 37, 1/4", 3/8", and 1/2" O.D. copper, aluminum, steel or polyethylene tubes spirally cabled together to permit bending without distortion. These tubes are completely protected from injury during and after installation by a flexible, interlocked, galvanized steel armor. One tube in each layer is a bright blue color, which makes identification of any tube an easy matter. This product is licensed under U. S. Patent 2,578,280.

*Registered Trade Mark

SEND FOR BULLETIN 356-A GIVING COMPLETE INFORMATION AND ENGINEERING DATA

CRESCENT INSULATED WIRE & CABLE CO.

Trenton 5, New Jersey

For more information circle **126** on inquiry card.

MARSH *Mastergauge*

Always the best of the better gauges, Mastergauge has been given *plus* features that further lengthen its lead.

A still better tube construction: Socket, tube and end piece are now all fused into *one* leak-tight unit by the new Marsh "Conoweld" process.

A still better case: New copper clad wrought steel "Marshalloy" case has the corrosion resistance of pure copper; weighs one third as much as cast iron, and is *four times* as strong.

An even finer movement: Further refinements are added to the rugged, corrosion resistant, virtually frictionless stainless steel and monel Mastergauge movement. A typical refinement is the "coined" (extruded) sector gear which contributes extra strength and precision.

Where only the best is good enough—in the most critical industrial refinery and oil country services —"Mastergauge" is your instrument.

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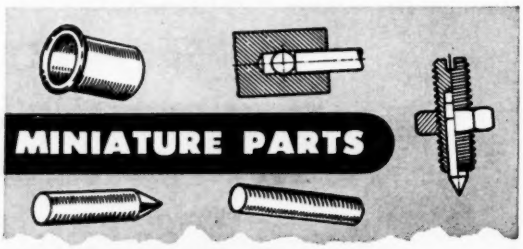
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alta.

For more information circle **127** on inquiry card.



CUSTOM MANUFACTURE of SMALL PARTS

Instrument Pivots
- As separate items or mounted in components—special steel, heat treated for maximum hardness, polished, metallographic finish. To specifications up to 3/8" diameter.

Shafts and Staffs
- Burrless, plain or alloy steel, heat treated to specifications. Metallographic finish.
- Tubular Products up to 3/8" Diameter, Cut, Flared, Swaged, Formed and Burr-Free. Alloy or Silver Plated.
- Screw-Machine Products up to 3/16" Diameter.

SERVICES FOR CUSTOMERS' PARTS
- A Multitude of Services are Available for Customers' Parts at Any Stage of Manufacture. These Include: Controlled-Atmosphere Heat-Treating, Centerless Grinding, Surface Grinding, Special Facilities for Ceramic Rods and Shapes, Knurling, Thread-Rolling to close tolerances, Swaging, Drilling, Milling, Burr Removing, Metallographic Polishing, Barrel-Plating in Alloy or Silver, light Punch-Press Work.

SPECIALTIES
- "Welton" noncorrosive paste solder for hairsprings or similar soldering.
- "Wentonoil" treated bottonwood pith for lubricating instrument pivots.

APPARATUS DESIGN SERVICES
- In Connection with the Design and Fabrication of Precision Miniature Parts.

ENGINEERING ASSISTANCE ON ALL ITEMS

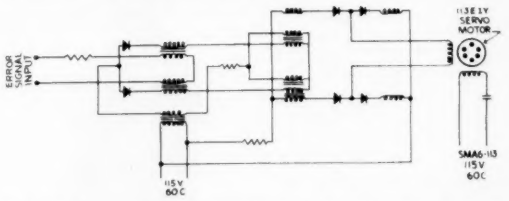
Welton V. Johnson
ENGINEERING COMPANY INC
92 SUMMIT AVENUE • SUMMIT N. J.

For more information circle **128** on inquiry card.

BRIEFS—CONTINUED

Servo Motors

In a servo system, the output of an error-sensing device is fed, after amplification, to the control winding on the servo motor stator. This varies the electro-magnetic field, thus controlling the speed and torque of the rotor. The servo motor, therefore, responds to the output of the error-sensing device. It acts to reposition the controlled object to the position indicated by the position signalling device . . . Typical applications of servo motors (include) direct plate-to-plate servo motor drive, transistor servo, amplifier drive, and magnetic amplifier drive.



For high torque outputs, where reliability is required in rugged environments, magnetic amplifier applications are desirable. The input impedance of the control winding of the servo motor shown (113E1Y) is such as to allow operation with an input voltage of 57.5 volts. This design permits extremely low temperature drifts and great reliability over the entire range of environmental temperatures. (*From new* 10*-page Bulletin* 385, *Norden-Ketay Corp., Precision Components Div., Jericho Turnpike, Commack, L. I., N. Y.*)

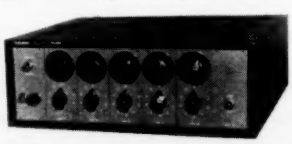
For this literature circle **405** on inquiry card.

Industrial Counting and Control Instruments

COUNTING STRIP

- STANDARD COUNTERS — hundreds of models . . . preset counters and totalizers.
- SPECIALIZED COUNTERS — modular construction permits reasonable prices.
- PLUG-IN STRIPS — to use in your own applications.

Low heat, long-life counting tubes and conservative design provide *Reliability in use* — over a year in constant operation without any servicing has been reported by satisfied industrial customers.



PRESET COUNTER

For information on various inputs, outputs, and counting units (up to 20,000 counts per second) . . . write for Industrial Bulletin — Edition II.

Sales Representatives in principal cities.

BAIRD ATOMIC

Baird–Atomic, Inc.

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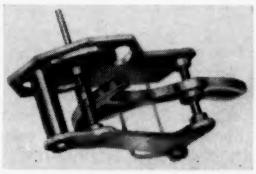
For more information circle **129** on inquiry card.

Bandrive Movement

BANDRIVE pressure gages incorporate a new concept in transmitting linear motion. Deflection of the Bourdon tube or pressure cell is transmitted to the indicating pointer of the gage without gears . . . The heart of this new



gearless type movement is the utilization of the patented long-deflection constant-force spring . . . BANDRIVE's inherent features eliminate backlash and lag between prime mover and pointer . . . (*From new 4-page Bulletin 403, Instrument and Systems Div., Norden-Ketay Corp., Wiley St., Milford, Conn.*)

For this literature circle **406** on inquiry card.

Chemical and Physical Tables

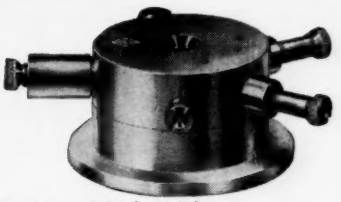
Absolute temperature—Temperature reckoned from the absolute zero.

Absolute zero—The temperature at which a gas would show no pressure if the general law for gases would hold for all temperatures. It is equal to −273.18°C or −459.72°F.

Acceleration—The time rate of change of velocity in either speed or direction.

Acceleration due to gravity—The acceleration of a body freely falling in a vacuum. The International Committee on Weights and Measures has adopted as a standard or accepted value, 980.665 cm/sec^2 or 32.174 ft/sec^2.

FOR MEASURING RADIOACTIVE EMISSION



8.3 x 6.5 x 3.5 cm. Weight 0.17 kg.

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Was first used for photo-electric measurements. Is now used in conjunction with ionization chambers for the determination of radioactive emission. Compact, sturdy, high sensitivity, stable zero and requires no leveling. Capacitance is about 3 cm. Includes improvements developed by the Ryerson Laboratory.

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is a personnel monitoring instrument to measure cumulative exposure to gamma or x-rays over a given period. Contains an ionization chamber; a quartz fibre electrometer and viewing system.

"CHANG AND ENG" FAST NEUTRON DETECTOR
follows closely original design of U. S. Atomic Energy Commission.

Consists of twin ionization chambers, Lindemann Electrometer, reading microscope and dry cells. Self-contained.

PRECISION IONIZATION METER (Failla Design)
A complete instrument for null methods of radioactivity measurement where background radiation effects must be eliminated.

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For more information circle **131** on inquiry card.

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Low-priced Stackpole slide switches provide practically any needed switching arrangement for appliances, instruments, radios, TV sets, small motors and electrical toys. They're sturdy, fully dependable, small in size.

22 STANDARD TYPES

Types from .5 to 3 amperes A.C. Underwriters approved. Write for Slide Switch Bulletin RC-9B to:

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STACKPOLE

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For more information circle **130** on inquiry card.

WANTED: Timing Problems

Chances are an economical stock timer (like these from Cramer's unusually flexible line) will meet your needs: If not, our engineers will be glad to work with you on specific problems. Write: Cramer Controls Corporation, Box 5, Centerbrook, Conn. 6.12

NEW INTERVAL TIMER, Type 241, features 12 full-scale time ranges from 6 seconds to 24 hours, easy-to-read dials. Provides push-button start, automatic stop and reset after timed interval.

RUNNING TIME METERS measure elapsed time intervals. Available to register in seconds, minutes, hours, and tenths of same; electrical stop clocks for smaller time intervals.

NEW TIME-DELAY RELAY, Type 412, also with ranges from 6 seconds to 24 hours, closes (or opens) a circuit at timed interval after closing control circuit. Nine position terminal block.

TALK IT OVER WITH CRAMER

CRAMER CONTROLS
CORPORATION
(Formerly R. W. Cramer Co.) 6.12

For more information circle **132** on inquiry card.

INSULATED WIRE
that will withstand
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Will last forever in service—eliminating costly replacement
• Available in outside diameters of .04 to .32.
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P.O. Box 150 • Perth Amboy, N. J.

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For more information circle **134** on inquiry card.

BRIEFS—CONTINUED

Acids—are substances whose molecules ionize in water solution to give the hydrogen ion from their constituent elements. The strength of an acid is proportional to the concentration of hydrogen ions present.

Beats—Two tones of slightly different frequencies sounded together interfere to give a sound of regularly varying intensity. The number of beats per second is the difference in frequency of the two tones.

Black body—If, for all values of the wave length of the incident radiant energy, all of the energy is absorbed, the body is called a black body.

Boyle's law for gases—At a constant temperature the volume of a given quantity of any gas varies inversely as the pressure to which the gas is subjected.

Capacitance—is measured by the charge which must be communicated to a body to raise its potential one unit.

Catalytic agent—A substance which by its mere presence alters the velocity of a reaction, and may be received unaltered in nature or amount at the end of the reaction . . . (*From new 124-page catalog "Tables and Data", United States Testing Company, Inc., 1415 Park Ave., Hoboken, N. J.*)

For this literature circle **407** on inquiry card.

Scale Feeders

Material flows onto a constant speed endless weigh-belt where it is carried over a scale section before discharging. The beam of this scale is the sensing element. The beam controls the flow of material onto the belt keeping the flow constant by weight. One type of Merchen Feeder is operated by means of an electro-mechanical system, in which deflections of the scale beam energize an electric

Frequent time adjustments are no problem with the dial head available on AGASTAT time/delay/relays. They provide a complete range of adjustment with 1 revolution of the dial. Dial markings permit easy calibration for accurate adjustment. And you can spot each of the 4 timing ranges quickly because they are color coded: blue from 30 seconds to 15 minutes; red from 10 seconds to 2 minutes; yellow from 0.1 to 10 seconds; white from 0.1 to 3 seconds.

Like all AGASTAT relays, units with dial heads are solenoid actuated, pneumatically timed. Each model is available with either dial head or needle valve adjustment. Where frequent readjustment of timing is necessary, dial head adjustment should be specified. For bulletin on all popular AGASTAT time delay relays, write to: Dept. A28-29.

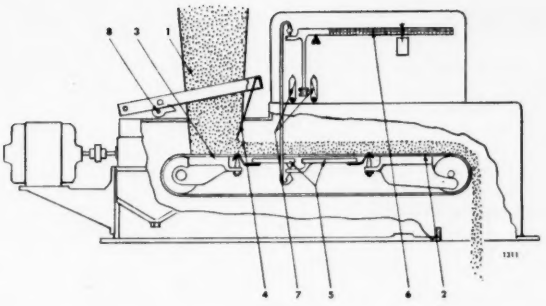
AGA DIVISION

Elastic Stop Nut Corporation of America

1027 Newark Avenue, Elizabeth, New Jersey

Pioneers in pneumatic timing

For more information circle **135** on inquiry card.



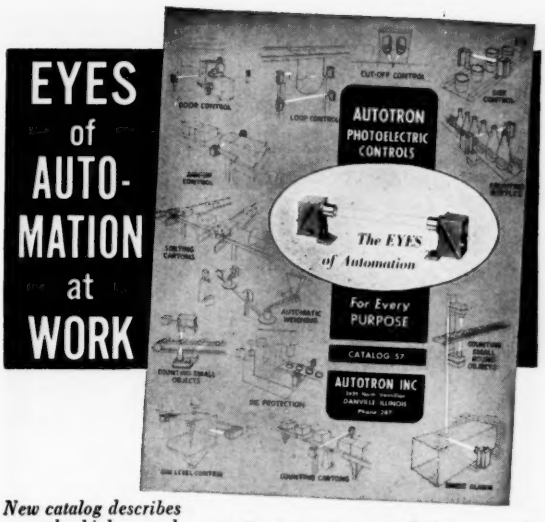
clutch to adjust the size of the opening in the feed section . . . (*From new 8-page Bulletin TA-1002, Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.*)

For this literature circle **408** on inquiry card.

The Evaporograph

The heart of the Evaporograph is a nitrocellulose membrane so thin that it reflects white light as a color, similar to the action of oil film on water . . . . Features: rapid production of two-dimensional heat picture from object's own infrared radiation . . . highly accurate temperature determinations over an entire surface . . . no physical contact or auxiliary illumination required . . .

When the clearing light is turned off, an oil film will immediately begin to build up. This condensation will be uniform, if the instrument shutter is kept closed to eliminate radiation from the field of view. The rate of condensation of this film is determined by cell heater setting. Viewed through the eyepiece the condensation process is evident as a series of colors. The membrane without oil



New catalog describes normal, high speed, ultra sensitive and impulse actuated photoelectric controls with safety relays, warm up protection, etc. Also photoelectric timing controls, and wide seletcion of light sources with many protective features.

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WRITE FOR ILLUSTRATED FOLDER WITH COMPLETE SPECIFICATIONS.

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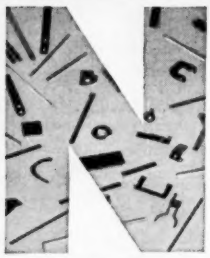
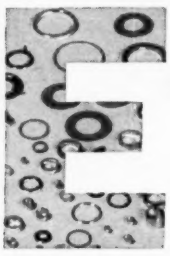
Dept. B-1

For more information circle **138** on inquiry card.

NEY'S SMALL PARTS PLAY A BIG PART IN PRECISION INSTRUMENTS



Ney's for "engineered" precious metal contacts, slip rings and alloys



Consult Ney's Engineering Dept. on any problem involving precious metals to improve your products.

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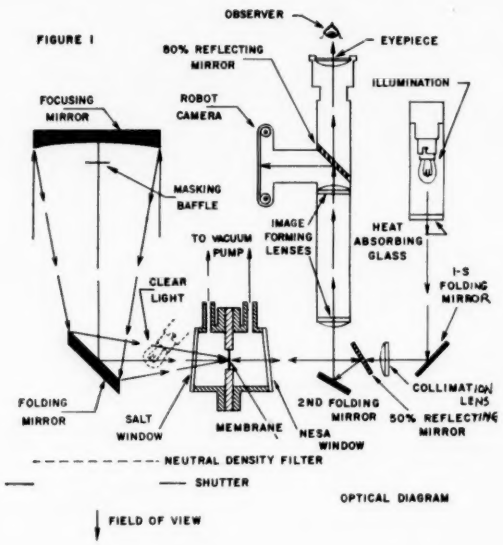
Specialists in Precious Metal Metallurgy since 1812

NEY'S SMALL PARTS PLAY A BIG PART IN PRECISION INSTRUMENTS

For more information circle **139** on inquiry card.

BRIEFS—CONTINUED



appears yellow. As oil deposits, the color changes to orange, then red, purple, dark blue, light blue, light green, and then greenish-yellow (second order). These colors are the interference colors . . . (*From new 12-page Bulletin RD-515, Baird Associates-Atomic Instrument Co., 33 University Rd., Cambridge 38, Mass.*)

For this literature circle **409** on inquiry card.

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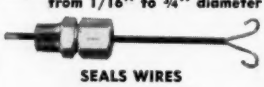
Any bore size available from 1/16" to ¾" diameter



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CONAX Packing Glands compress the "soft" sealant against any kind of tube, rod or wire with the following advantages:—

- Temperature range: —300°F to +1850°F.
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For more information circle **140** on inquiry card.

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FOG TEST CHAMBER

To Meet MIL-E-5272A and others

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Manufacturers of Environmental Test Equipment
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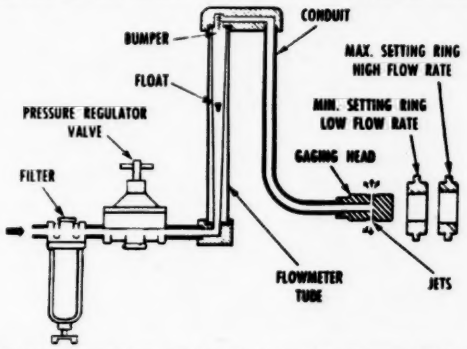
For more information circle **141** on inquiry card.

Air Gaging

Principle of operation is exactly the same in multiple as in single column instruments . . . Air flows upward through a vertical internally tapered, transparent glass column in which a metal float moves up and down according to the flow of air.

The air flows out through a plastic or rubber hose to the gaging spindle, Airsnap or other device. Velocity and volume of the air flow are determined by the clearance between the gaging device and the part being gaged, and are



indicated by position of the float in the column. The float rises as flow increases—float falls as flow decreases.

A gaging spindle similar to a plug gage having a central air passage and diametrically opposed air jets, gages the true diameter of a hole. Two master setting rings having internal diameters equivalent to the minimum and maximum tolerance limits, enable the Precisionaire to be calibrated for correct amplification and the limit markers to be properly set. (*From new 12-page Catalog IPC 6-56, The Sheffield Corp., Dayton 1, Ohio*)

For this literature circle **410** on inquiry card.

Check and calibrate any type of thermocouple-actuated temperature instrument with one portable Pyrotest

Read temperatures or millivolts directly . . . without graphs, charts or conversion tables

The only portable potentiometer pyrometer with interchangeable direct reading scales

Pyrotest is 9 instruments in one, with 6 standard scales for thermocouples; 3 standard scales for millivolt readings. Special scales for any desired reading or use. Scales interchangeable in 30 seconds. Compact, rugged, easy to carry—12 lbs.; 12" x 9" x 8½". Accurate to 1/6 of 1%. Self-contained power supply. Write for new bulletin 9B.

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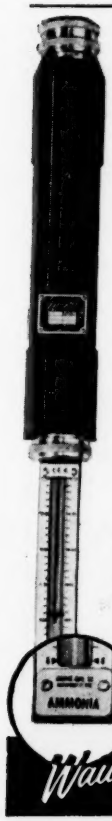
INDIANAPOLIS 25, IND.

For more information circle **143** on inquiry card.



the meter with the tell-tale TAB

Waukee

FLO·METER

No one can mistake what gas the Waukee FLO-METER is measuring — because a Waukee TAB with large RED letters is affixed to the bottom of the scale and *shouts* to your operator whether the meter is measuring hydrogen, ammonia, or any other gas.

TABS are available for all gases listed below, and many others — an exclusive Waukee feature.

Waukee's TABS, built-in Control Valve, panel-mounting design, 5-minute cleaning, large easy-to-read scale — all mean simple installation, clean appearance, accurate operation. Time and money-saving features.

Complete information in Bulletin 203. Write for it. **Waukee Engineering Company,** 5137 North 35th Street, Milwaukee 9, Wisconsin

For measuring: air — ammonia — dissociated ammonia — argon — butane — city gas — endothermic cracked —exothermic cracked — forming gas — helium — hydrogen — natural gas — nitrogen — oxygen — propane.

Waukee FLO-METERS • AIR GAS MIXORS
INDUSTRIAL WASHING MACHINES

For more information circle **142** on inquiry card.

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applied by the inch ounce

Available in these Torque Ranges

MODEL	CAPACITY
F80-I-G	0- 80 inch grams
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F32-I-O	0- 32 inch ounces
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Inch pound models and larger foot pound ranges also available

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ADDISON QUALITY ILLINOIS

For more information circle **144** on inquiry card.

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CRANE SCALE

Weighs heavy loads suspended from crane hook. Printer, located in crane cab or other convenient location, records weight on tape or cards. New compact printer only 22" x 18" x 10½".

Entire assembly designed for prompt and easy installation. Now available at new low cost. Capacities 5 10 15 tons

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Branches in Detroit, Allentown, Birmingham and Los Angeles.

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DC-AC CHOPPERS

For 60 Cycle Use

Built to rigid commercial specifications.

Twenty-two types, both single and double pole.

Long life.

Low noise level.

Extreme reliability.

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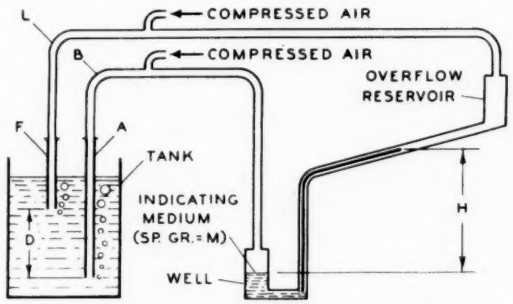
S/A-10

For more information circle **146** on inquiry card.

BRIEFS—CONTINUED

Specific Gravity Indicator

The Petrometer Indicator No. 1561 is a remote reading instrument for determining the specific gravity of liquids . . . The indicator works on the principle of a differential bubbler and has two (2) static pick-up tubes (one a predetermined distance above the other) within the vessel containing liquid subject to test.



The indicating system consists of a combined vertical and inclined manometer equipped with an adjustable well and safety overflow. It has two identical air bubbler generators, each consisting of a flowmeter and needler valve, one for the upper and one for the lower set of static tubes . . . (*From new 4-page Bulletin* 7004, *Petrometer Corp.*, 43-22 *Tenth St., Long Island City* 1, *N. Y.*)

For this literature circle **411** on inquiry card.

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TOOLMAKERS MICROSCOPE

WITH INTERCHANGEABLE DIAL TEMPLETS AND OCULARS

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58
59
Reading Angles in Minutes
Thread Templets for U. S. National Thread Profiles-6-80 Pitch. Radii Templets, etc.
LARGE MICROMETER DRUMS READ DIRECTLY IN .0001"
Measuring Range 2" x 1-1/2" and other sizes
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ACCURACY

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GEORGE SCHERR CO., Inc.
COMPLETE LINE OF PRECISION INSTRUMENTS
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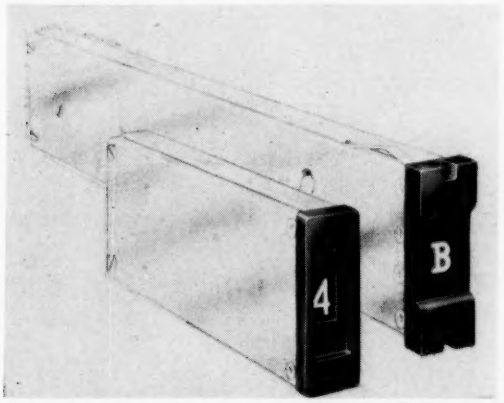
For more information circle **147** on inquiry card.

Digital Indicator

The operation of the UNION Digital indicator is based on a positioning system utilizing a four-bit binary code. Ten character positions of a possible sixteen are used. The relation of the visible character to its code for the standard Digital indicator is the direct translation of binary coded decimal notation to decimal . . .

The indicator is internally powered by a small D.C. permanent magnet motor. A mismatch between a trans-



mitted code and that commutated by the indicator will complete the circuit, causing the motor to operate . . . The Digital indicator is being used in pipeline control systems, wherein the indicator is used for displaying and storing telemetered data such as temperature, pressure, flow, etc., in a central office . . . (*From new 8-page Bulletin* 1011, *Union Switch & Signal, Div. of Westinghouse Air Brake Co., Pgh.* 18, *Pa.*)

For this literature circle **412** on inquiry card.

MELTING POINT

Temperature Standards

FOR PRECISION CALIBRATION OF THERMOCOUPLES AND RESISTANCE THERMOMETERS

Calibration to .01 C. possible
Long dwell at melting point
Takes 8 mm. thermometers
Operates on 115 volts A.C.

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Sodium • Tin • Lead
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For more information circle **149** on inquiry card.

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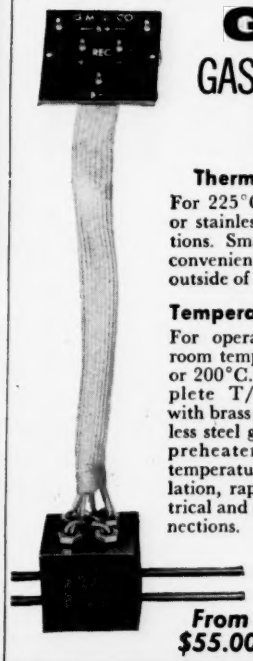

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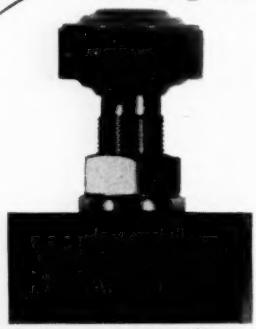

- Hi Vacuum to 6000 PSI.
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INSTRUMENTS and AUTOMATION

New Literature

AUTOMATION

Transport Control System. New 8-page Brochure SPL 1052 describes company's Centralized Transport Control system (CTC) and methods of applications.— Union Switch & Signal Div. of Westinghouse Air Brake Co., Swissvale, Pa.
Circle **413** on inquiry card.

Photoelectric Controls. New 4-page bulletin describes maker's "Robot-Eye" photo electric controls featuring miniaturized components. — Standard Instrument Corp., Robot-Eye Photo Control Div., 657 Broadway, New York 12, N. Y.
Circle **414** on inquiry card.

Photoelectronic Edge Control. Two new 4-page Bulletins provide information on maker's "Edgetrol" photoelectronic edge guidance systems includes 3 illustration sheets.—Intercontinental Dynamics Corp., 170 Coolidge Ave., Englewood, N. J.
Circle **415** on inquiry card.

MOTORS, SERVOS

Servo Mechanism Components. New 2-page Bulletin 410 describes maker's high-temperature servo mechanism components.—Norden-Ketay Corp., Commerce Rd., Stamford, Conn.
Circle **416** on inquiry card.

Synchros. New 4-page Bulletin 409 presents specifications of maker's 3 minute, Size 23 synchros.—Norden-Ketay Corp., Western Div., 13210 Crenshaw Blvd., Gardena, Calif.
Circle **417** on inquiry card.

Servo Unit. New 2-page bulletin describes maker's "BuOrd Size 10" miniature motor-gearhead-clutch.—Servomechanisms, Inc., Mechatrol Div., 625 Main St., Westbury, L. I., N. Y.
Circle **418** on inquiry card.

Servo Motors. New 4-page bulletin presents specs for low-inertia servo motors.—Bekey Electric Co., Inc., 1327 S. Main St., Los Angeles 15, Calif.
Circle **419** on inquiry card.

Gear Motors, Counters. New 12-page brochure describes maker's fractional horse power shaded pole gear motors and counters.— Electro Counter & Motor Co., 1713 N. Ashland Ave., Chicago 22, Ill.
Circle **420** on inquiry card.

Servo Amplifiers. Two new 2-page bulletins presents maker's line of servo amplifiers for 60 and 400 cps servo motors.—Industrial Control Co., Wyandanch, L. I., N. Y.
Circle **421** on inquiry card.

VALVES

Control Valves. New 4-page Bulletin 114R pictures and describes maker's air operated Saunders-type control valves for chemicals slurries. —Uniflow Valve Corp., 19 Quine St., Cranford, N. J.
Circle **422** on inquiry card.

Pinch-type Valves. New 6-page Bulletin FL-116 contains illustrations and specs of maker's pinch-type valves for manual or actuator operation.— Farris Flexible Valve Corp., 400 Commercial Ave., Palisades Park, N.J.
Circle **423** on inquiry card.

Valve Guide. New 20-page Circular No. 555 shows new LQ600 Bronze Globe valves, with Brinalloy Seats and Discs; Luncor PVC All-Molded Valves and maker's Solder End Valves, along with tables and technical data information.—Lunkenheimer Co., Cincinnati 14, Ohio.
Circle **424** on inquiry card.

Shut-off Valves. New 4-page Bulletin 500 describes maker's shut-off guarding against excess flow, high or low pressure, or over temperature. —Coppus Engineering Corp., Worcester, Mass.
Circle **425** on inquiry card.

Combustion Safeguards. New 12-page Bulletin SC 1006 describes operation and construction of maker's automatic fire checks for detecting, localizing and extinguishing flashback in mixture supply lines.—Selas Corp. of America, Dresher, Pa.
Circle **426** on inquiry card.

TEMPERATURE

Thermistor Temperature Control. New 2-page Data Sheet 5 presents operation, applications, ranges and prices for themistor-actuated "Simplytrol" for temperature control or alarm.—Assembly Products, Inc., Wilson Mills Road, Chesterland, Ohio.
Circle **427** on inquiry card.

Indicating Pyrometer. New 4-page Bulletin 64 describes maker's potentiometer-type "MiniMite" portable pyrometer indicator.—Thermo Electric Co., Inc., Saddle Brook, N. J.
Circle **428** on inquiry card.

Temperature Regulators. Two new 4-page Bulletins 329 and 316 describe maker's "No. 11" self-operating regulator which automatically controls temperature of liquids and air; Bulletin 316 describes "Accritem" regulator for controlling liquid or air temperatures in commercial and industrial processes.—The Powers Regulator Co., 3400 Oakton St., Skokie, Ill.
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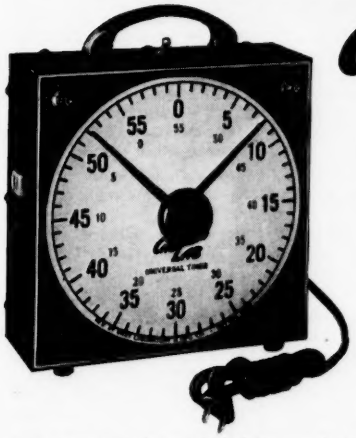

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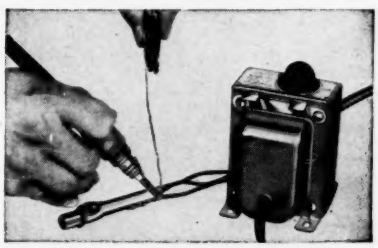

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Smaller, lightweight — for easy handling over prolonged periods of time. Thermo-Tip Tools are expressly designed as a production line tool. Reduces fatigue factor for women workers.

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The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

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NEW LITERATURE

Temperature Control. New 21-page illustrated Brochure GER-1206 describes maker's industrial furnace temperature control.—General Electric Co., Schenectady 5, N. Y.

Circle **430** on inquiry card.

Contact Pyrometer. New 12-page Bulletin 4257 shows applications and presents specs, prices, and temperature ranges for surface-temperature contact pyrometer.—Illinois Testing Labs., Inc,, 420 N. La Salle St., Chicago 10, Ill.

Circle **431** on inquiry card.

Thermopiles. New 12-page Brochure CH 313/5 describes Hilger-Schwarz Thermopiles for conversion of infrared energy into electrical energy. —Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

Circle **432** on inquiry card.

Thermostats. New 2-page Bulletin 9000 announces Stemco Type B Thermostats for table appliances and Stemco Tip-Over Switches with principles of operation, specification data, ratings, etc. New 2-page Bulletin 5000 describes "Type C" Thermostats. —Stevens Mfg. Co., Inc., Lexington, Ohio.

Circle **433** on inquiry card.

Pyrometer Tester. New 8-page Bulletin 9B contains description of maker's portable potentiometer pyrometer with numerous illustrations. Can be used for calibrating any type of thermocouple-actuated instrument. —Technique Associates, 211 E. South St., Indianapolis 25, Indiana.

Circle **434** on inquiry card.

FLOW, PUMPS, LIQUID LEVEL

Rotameters. Four new bulletins (116, 130, 145 and 360) present information and data on maker's by-pass rotameters, armored rotameters, hi-pressure indicating, and "Model 3602" armored flow indicators.—Brooks Rotameter Co., Lansdale, Pa.

Circle **435** on inquiry card.

Vacuum Transmitter. New 2-page Catalog 70-27 describes and illustrates maker's rotating vacuum transmitter for automatic chlorine proportioning. —Fischer & Porter Co., 906 Jacksonville Rd., Hatboro, Pa.

Circle **436** on inquiry card.

Liquid Level Gage. New 2-page leaflet (Unit 291 Supplement) describes maker's new remote reading gages with inclined scale.— Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

Circle **437** on inquiry card.

Volumetric Feeder. New 4-page Bulletin 65-H12B pictures and describes maker's "Model 65" Rotodip continuous volumetric feeder for liquids.— Omega Machine Co., Div. of B-I-F Industries, Inc., Providence 1, R. I.

Circle **438** on inquiry card.

Electro-Caloric Flowmeter. New 4-page bulletin describes operation of electro-caloric flowmeter that measures and totalizes flow by measuring heat transfer through boundary layer.—Industrial Development Labs., Inc., 17 Pollock Ave., Jersey City 5, N. J.

Circle **439** on inquiry card.

Hydrological Instruments. New 22-page Bulletin 700 contains description and pertinent data of maker's current meters, water level recorders, hook gages, rain gages, wind instruments etc.—W. & L. E. Gurley, Industrial Div., Troy, N.Y.

Circle **440** on inquiry card.

Fluid Proportioneer. New 4-page bulletin 1140 describes maker's "Model 1140" chemical proportioning pumps. —Proportioneers, Inc., Div. of B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.

Circle **441** on inquiry card.

Liquid and Gas Control. New 36-page General Catalog No. 005 covers the equipment for measurement and control of liquids and gases, illustrating types of controllers, gages, manometers, recorders, meters, valves, etc.—Simplex Valve and Meter Co., Lancaster, Pa.

Circle **442** on inquiry card.

Eductors. New 2-page Bulletin Supplement 2M-PVC describes and illustrates maker's polyvinyl chloride "Fig. 264" eductors for liquid pumping and mixing operations.—Schutte and Koerting Co., Cornwells Heights, Bucks County, Penna.

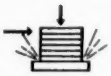
Circle **443** on inquiry card.

Pumps. New 4-page Bulletin 856-2 describes and illustrates maker's "Little Giant" pumps for low volume, medium pressure, chemical metering applications. 2-page Bulletin 856-1 presents "Mity-Mite" auxiliary series of chemical metering pumps for low volume, boiler chemical feed applications.—Orchem Pumps, Inc., 4434 Salmon St., Phila. 37, Pa.

Circle **444** on inquiry card.

Chlorinizers. New 4-page Bulletin 840-N10 gives schematic illustration of maker's chlorine gas feeders, and describes operation, control variations, etc.— Builders-Providence, Inc., Div. of B-I-F Industries, Inc., Providence 1, Rhode Island.

Circle **445** on inquiry card.



PRESSURE, WEIGHT

Pressure Gages. New 2-page leaflet shows features of new safety gages with cast partition between mechanism and dial. Lists available sizes, prices, and types.—Weksler Thermometer Corp., 195 E. Merrick Rd., Freeport, L.I., N.Y.

Circle **446** on inquiry card.

Strain Gages. New 16-page price list contains all information for the selection of SR-4 strain gages, and methods of using them; also new types of flat grid, fine pitch, bakelite gages.—Baldwin-Lima-Hamilton Electronics and Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.

Circle **447** on inquiry card.

Pressure Gage Snubbers. New 4-page Catalog 4395 presents maker's fluid system specialties including tube clips, dual heat transfer coil, pressure gage snubber, and draft gage manifold valve.—The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12. Ohio.

Circle **448** on inquiry card.

Electronic Load Cell Scales. New 4-page Bulletin 2970 describes and illustrates maker's electronic load cell scales for remote indication and recording of weights.—Toledo Scale Co., Toledo, Ohio.

Circle **449** on inquiry card.

Pneumatic Transmitter. New 4-page bulletin illustrates pneumatic force-balancing transmitter for temperature, gage or absolute pressure.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Ave's., Phila. 44, Pa.

Circle **450** on inquiry card.

Scale Feeder. New 4-page Bulletin TP-6-M pictures and describes maker's Merchen pneumatic scale feeder.—Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.

Circle **451** on inquiry card.

Pressure Pickups. New set of 20 two-page data sheets for F3 catalog present specifications for maker's pressure pickups.—Wiancko Engineering Co., 255 N. Halstead Ave., Pasadena, Calif.

Circle **452** on inquiry card.

Pressure Intensifiers and Pumps. New 30-page catalog presents specs for maker's line of high-pressure intensifiers and pumps.—Harwood Engineering Co., Inc., South St., Walpole, Mass.

Circle **453** on inquiry card.

Counting Scales. New 8-page Bulletin 1154 describes and illustrates maker's ratio counting scales.—Toledo Scale Co., Toledo, Ohio.

Circle **454** on inquiry card.

Gross Weigher. New 6-page Bulletin No. 0356 contains all information on maker's Model E-52 Automatic Gross Bagger for adhesive and non-adhesive materials.—Richardson Scale Co., Clifton, N. J.

Circle **455** on inquiry card.

TIME, SPEED

Resonant Reed Tachometers. 16-page Bulletin 31 presents specs for mounted and portable resonant reed tachometers.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.

Circle **456** on inquiry card.

Delay Timer. New 2-page Bulletin 651 pictures and describes maker's "Type EHS" electronic delay timer.—G. C. Wilson & Co., Huntington, W. Va.

Circle **457** on inquiry card.

Stroboscope. New 4-page Bulletin Bln 7 presents Deuta hand stroboscope for optical and mechanical measurement of speed and slow motion.—Epic, Inc., 154 Nassau St., New York 38, N. Y.

Circle **458** on inquiry card.

Adjustable Speed Drive. New 4-page Catalog 2956 contains all information on maker's "Series 300' electronic adjustable-speed drive.—2-page Catalog Sheet 1856 describes d-c tachometer generator.—Servo Tek Products Co., Inc., 1086 Goffle Rd., Hawthorne, N. J.

Circle **459** on inquiry card.

Electronic Counters. New 6-page leaflet illustrates maker's universal counter-timers, frequency and period counters, time-function translators,

ONE Instrument Now Controls Temperatures From MANY Points

T-E's New Multi-Point Controller

This new, Multi-Point, Pyrometer Controller now provides—in one instrument—automatic temperature control for up to ten *separate* process units. Alone, it handles installations that formerly required as many as ten individual instruments. Immediate advantages are obvious—a great reduction in necessary panel board space, a tremendous decrease in initial cost, much lower maintenance costs, and the time-saving convenience of setting and observing temperature controls at one location.

It applies to practically any installation suitable for two-position control action—creep test machines, multi-zone ovens and furnaces, laboratory aging and reaction vessels, batteries of batch process units, and many others. Simple adjustments permit skipping of one or more points—providing optional control of four to ten units. Control settings consist of ten separate slide wires with ten individual set points. Red and green signal lamps indicate temperature conditions for each point. Scale ranges for all calibrations run from −400° F. with C-C to +3250° F. with Plat. 30% Rh.–Plat. 6% Rh.

Measuring Accuracy is insured by the null balance potentiometer measuring circuit, which permits calibration independent of thermocouple and extension wire resistance. Potentiometer accuracy depends on the stability of fixed circuit resistors, not on less dependable mechanical elements.

Operating Speed is usually three seconds per point, 30 seconds for all 10 points. Gears for other speeds are available and easily changed in the field.

High Sensitivity starts corrective action after deviation from set point of only 1° F. for I-C and 1.5° F. for C-A.

Write for EDS-25-F.

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In Canada — THERMO ELECTRIC (Canada) Ltd., Brampton, Ontario

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NEW LITERATURE

preset controllers, totalizing counters, time interval meters, and decade and preset decade counting units.—Computer-Measurements Corp., 5528 Vineland Ave., North Hollywood, Calif.

Circle **460** on inquiry card.

OPTICAL

Monochromator. New 4-page Bulletin 811R pictures and describes maker's monochromators for wavelengths between 220 and 2800 millimicrons.—Farrand Optical Co., Inc., Bronx Blvd. & East 238th St., New York 70, N. Y.

Circle **461** on inquiry card.

Magnifiers. New 12-page Bulletin 1-52,60 presents maker's line of readers and magnifiers and discusses theory and purpose of various types of magnifiers.—Bausch & Lomb Optical Co., Rochester 2, N.Y.

Circle **462** on inquiry card.

Cameras. Seven new 2-page Data Sheets (7123, 7124, 7125, 7126, 7127, 7129, 7133) describes Bell & Howell "200-P" 16-mm magazine pulse camera; '198" portable splicers; "70-KRM" 16-mm motion picture camera; "71-QM, 71-KM, 71-MM, 71-RM," 35-mm motion picture cameras.—Traid Corp., 4515-17 Sepulveda Blvd., Sherman Oaks, Calif.

Circle **463** on inquiry card.

Photographic Slide Rule. New Photographic slide rule permits easy conversion of feet of film to running time, or the reverse, for all frame rates and film sizes.—Flight Research, Inc., P.O. Box 1-F, Richmond, Virginia.

Circle **464** on inquiry card.

Interference Filters. New 16-page Bulletin 302 describes German made monochromatic interference filters.—Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N. Y.

Circle **465** on inquiry card.

VISCOSITY

Viscometer Recorders. New 2-page Bulletin V-1217 describes maker's line of viscometer recorders "Series R3".—Norcross Corp., 247 Newtonville Ave., Newton 58, Mass.

Circle **466** on inquiry card.

Viscometers. New 6-page Bulletin 17 includes the Cannon-Manning Semi-Micro viscometer and the Cannon-Ubbelohde Dilution viscometer (for intrinsic viscosity measurement), in addition to the Cannon-Fenske viscometers for transparent and opaque liquids, and Ubbelohde viscometers, etc.—Cannon Instrument Co., Box 812, State College, Pa.

Circle **467** on inquiry card.

VIBRATION

Vibration Measurement. New 20-page issue of "Technical Review" (Dec., 1956) describes current applications and potential uses of sound, vibration and strain measuring instruments.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle **468** on inquiry card.

Vibration Measurement. New 4-page bulletin describes maker's displacement follower for measuring displacement, runout or vibration of mechanical parts. Includes three 2-page specification sheets.—Optron Corp., 3526 State St., Santa Barbara, Calif.

Circle **469** on inquiry card.

AIR, GAS, SMOKE, STEAM

Power Trap. New 2-page Bulletin 501 describes maker's "Mag-Pneu-Power" trap for discharging condensate in compressed air and gas lines.—Hankison Corp., 951 Banksville Rd., Pittsburgh 16, Pa.

Circle **470** on inquiry card.

Combustion Analyzer. New 4-page Bulletin E65-5 describes combustion analyzer for any type furnace using any type fuel.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Circle **471** on inquiry card.

Dehydrators. New 2-page leaflet illustrates and describes maker's three new types of "Dehydrafilters" used to remove moisture and oil vapors from instrument air lines.—Hankison Corp., 951 Banksville Rd., Pittsburgh 16, Pa.

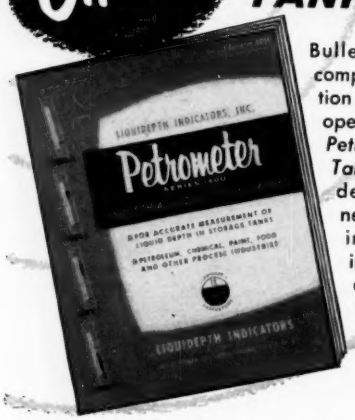
Circle **472** on inquiry card.

Gas Dehydration. New 8-page Brochure 1157 describes maker's gas dehydration system.—Robbins Aviation, 1735 W. Florence Ave., Los Angeles 47, Calif.

Circle **473** on inquiry card.

Cooling Fans. New 4-page illustrated catalog provides information and data on maker's rack mounted electronic cabinet cooling fans.—Mc-

How to Choose THE RIGHT REMOTE READING TANK GAUGE



Bulletin 6004 presents comprehensive information on the selection and operation of the *New Petrometer Series 1400 Tank Gauges.* It also describes the many new design features incorporated in the indicators to provide quick, easy installation, trouble-free automatic operation and accurate indication.

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Petrometer CORPORATION

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* Complete Optical Instruments made to Specifications.
* Design and Manufacture of Optical Systems using Glass, Crystal or other Transmission Media.
* Lenses and Prisms of Many Types.
* Test Glasses.

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PRECISION OPTICS

2759 Frankford Ave., Philadelphia 34, Pa.

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Lean Engineering Labs., P. O. Box 228, Princeton, N. J.

Circle **474** on inquiry card.

Fans. New 32-page set of engineering data sheets describes and illustrates maker's fans and blowers, including information on pumps and motors.—Rotron Manufacturing Co., Inc., Schoonmaker Lane, Woodstock, N. Y.

Circle **475** on inquiry card.

Pneumatic Standards. New 12-page issue of Ross enginAir (Vol. 2, No. 2) discusses air circuits and includes standards recommended by JIC pertaining to air motors and cylinders.—Ross Operating Valve Co., 120 E. Golden Gate, Detroit 3, Mich.

Circle **476** on inquiry card.

LABORATORY, ANALYTICAL

Electrolytic Conductivity. New 16-page Catalog No. 22 provides data and prices of electrolytic conductivity equipment for measurement and control of solution concentration.—Industrial Instruments Inc., 89 Commerce Road, Cedar Grove, Essex County, N. J.

Circle **477** on inquiry card.

Color Difference Meter. New 2-page Data Sheet No. 10.10-6 describes operation of Gardner automatic color difference meter that compares three variables in any two colors. Includes Brown Instruments' amplifier and two-phase balancing motors in measuring circuit.—Address inquiries to Gardner Laboratory, Inc., Bethesda 14, Md.

Circle **478** on inquiry card.

Laboratory Equipment. New 24-page issue of "What's New" (No. 27) presents descriptions of laboratory equipment, including Beckman gas chromatograph for analyzing gases and low-boiling liquids, Jelrus controlling pyrometer, Photovolt electronic pH tester, Pandux recording thermometer, etc.—Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

Circle **479** on inquiry card.

pH Meter. New 4-page Circular 195 gives specifications and prices of maker's line-operated pH meter Mod. 85.—Photovolt Corp., 95 Madison Ave., New York 16, N.Y.

Circle **480** on inquiry card.

Laboratory Equipment. New 16-page issue (January, 1957) of "Laboratory" describes and illustrates new Beckman gas chromatograph, and pH meter tester; Voland balances; pumps, timers, etc.—Schaar and Co., 754 W. Lexington St., Chicago 7, Ill.

Circle **481** on inquiry card.

Laboratory Supplies. New 4-page bulletin illustrates and specifies maker's "Pioneer" polyethylene labware.—Palo Laboratory Supplies, 81 Reade St., New York 7, N. Y.

Circle **482** on inquiry card.

Analyzer. New 4-page brochure describes maker's "Bichromator" analyzer for continuous single component measurement in a process stream.—Perkin-Elmer Corp., Norwalk, Conn.

Circle **483** on inquiry card.

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The ever increasing use of atomic and nuclear energy in manufacturing and processing industries requires ultimate safety measures for the protection of *all persons,* even those casually exposed to radiation. Radio active products affect not only people involved in production processes but in all handling services such as receiving, shipping and transportation. And it is these marginal contacts that can be most severely affected by radiation, for which Victoreen Personal Dosimeters offer a complete measurement of safety.

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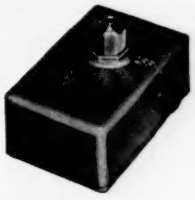
Victoreen Pocket Dosimeters are about the size of a pen and clip into the pocket. After being charged on the 561A Dosimeter Charger, to zero position, radiation exposure causes leakage which is reflected on a direct reading scale built into the pocket dosimeter. User need only hold Pocket Dosimeter toward a bright light —look into tube and read the accumulated roentgen dose.

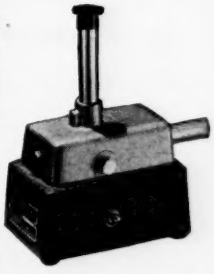


INDIRECT READING POCKET DOSIMETERS

When a group of people must be safeguarded against radiation over periods of time, the indirect reading personal dosimeter instrumentation has several advantages. Daily x-ray exposure methods can be maintained, establishing medical and legal evidence of daily exposure and improved personnel relations are acquired as a result of more than adequate health-safety measures.

You can OWN a Minometer and Dosimeters for less than the cost of film badge service for 8 or more individuals.

Individual Pocket Dosimeters are charged by the Model 287 Minometer. After each days exposure, pocket dosimeters are read on the Minometer, thereby establishing an accurate day-by-day record of x-ray exposure for each individual.



STRAY RADIATION CHAMBERS

Available for use with the Minometer are stray radiation chambers for detecting and measuring x-ray or gamma radiations in any area suspected of being subject to the hazards of stray radiation. Chambers are quickly charged and exposure accurately measured on the Minometer.

Illustrated catalog, giving detailed specifications of all Victoreen Dosimeter Instruments available on request. Ask for Bulletin 3042.

SPECIAL AREA MONITORS AND SYSTEMS

Victoreen manufactures a variety of special instruments for measuring the radiation level in hazardous locations and initiating alarms and/or interlocks if the level is either higher or lower than a pre-set intensity. This includes radiation proof alarms for very high intensity sources as well as low level personnel monitoring. We welcome inquiries for special multi-station monitoring devices designed to your requirements.

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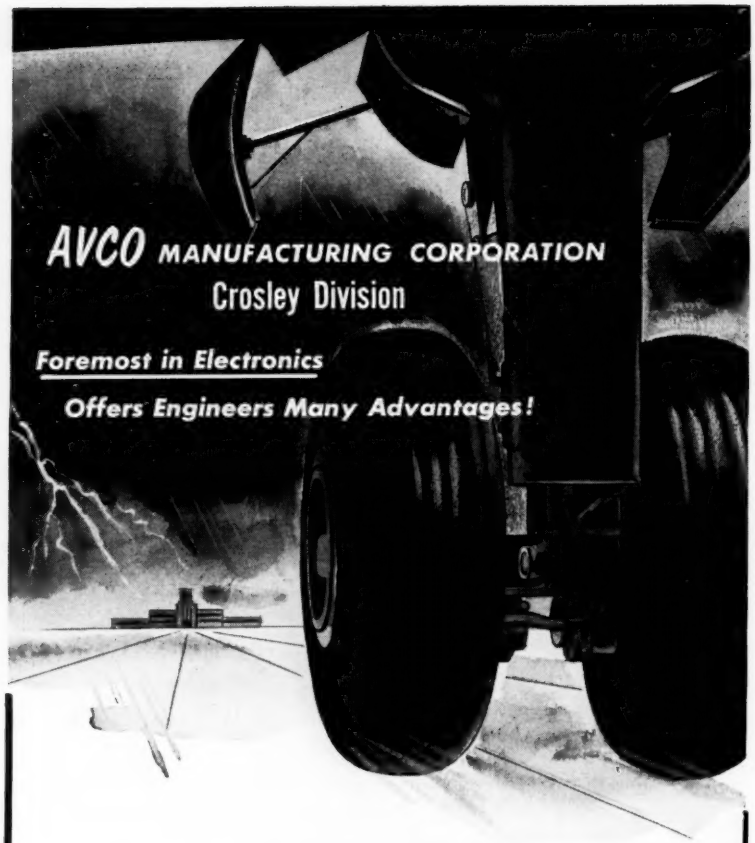

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Fluorometer. New 8-page Bulletin 803R describes maker's photoelectric fluorometer for measuring low concentrations in micro or macro volumes of solutions.—Farrand Optical Co., Inc., Bronx Blvd. and East 238th St., New York 70, N. Y.

Circle **484** on inquiry card.

Fluorimeter. New 2-page edition of "Newsletter" (Vol. 3, No. 18) contains description of maker's Midget Fluorimeter used for qualitative and quantitative determination of chemical substances by fluorescence analysis.—Gardner Laboratory, Inc., P. O. Box 5728, Bethesda, Md.

Circle **485** on inquiry card.

Thermal Conductivity Analyzer. New 12-page Catalog 56-1008-59 describes and illustrates applications and features of maker's "Condu-Therm" analyzer and "Acratron" electronic recorder.—The Hays Corp., Michigan City, Ind.

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Fluorescent Analysis. New 2-page Bulletin FAC 9-56 pictures and describes maker's "Mineralab" flourescence analysis cabinet for identification with ultra-violet light.—Ultra-Violet Products, Inc., San Gabriel, Calif.

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Chromatography. New 24-page Catalog 1356 lists and illustrates apparatus and accessories for both paper chromatography and column chromatography. Includes price list.—Research Specialties Co., 2005 Hopkins St., Berkeley 7, Calif.

Circle **488** on inquiry card.

Cryoscope Osmometer. New 2-page Bulletins C1 and O1 present chemical purity Cryoscope for dairies, chemical plants, bottlers; and Osmometer for clinical pathologists and electrolyte laboratories.—Advanced Instruments, Inc., Needham 92, Mass.

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Gas Analysis. New 4-page bulletin GMH 9-56 gives complete data and specifications on maker's "Gas Master" analyzers for evaluating the thermal conductivity properties of gases in mixtures. Includes extensive bibliography.—Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J.

Circle **490** on inquiry card.

COMPUTERS

Digital Computer. New 6-page illustrated Bulletin AB116 provides information and data on maker's G-15D digital computer.—Bendix Computer Div., Bendix Aviation Corp., 5630 Arbor Vitae St., Los Angeles 45, Calif.

Circle **491** on inquiry card.

Analog Computer. New 16-page catalog describes maker's d-c analog computers and allied equipment.—Mid-Century Instrumatic Corp., 611 Broadway, New York 12, N. Y.

Circle **492** on inquiry card.

Computer Services. New Cook Research Newsletter, Vol. No. 6, Issue 2, lists the digital and analog equipment contained in their expanded computer facility service.—Cook Electric Co., 2700 No. Southport Ave., Chicago 14, Ill.

Circle **493** on inquiry card.

RECORDERS

Rectilinear Recorder. New 10-page Bulletin R-501 contains all important information on maker's rectilinear recorder and accessories changing curvilinear motion to true rectilinear motion.—Houston Technical Laboratories, 3609 Buffalo Speedway, Houston 6, Tex.

Circle **494** on inquiry card.

Oscillograph. New 4-page illustrated bulletin provides information and data on maker's "Type 401" low-frequency oscillograph and "Type 404" pulse-generator.—Allen B. DuMont Labs., Inc., Clifton, N. J.

Circle **495** on inquiry card.

Tape Recorder. New 26-page Bulletin 1561B describes and illustrates maker's multi-channel magnetic tape recording and playback system for recording stress, pressure. temperature and vibration.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **496** on inquiry card.

Operation Recorders. New 4-page Bulletin 1156 contains information on maker's operation recorders showing illustrations of records taken from various applications in transportation and plants.—The Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis 6, Ind.

Circle **497** on inquiry card.

Pressure Recorders. New 4-page Catalog 1021 describes and illustrates maker's multi-pen circular chart recorders for pressure and temperature elements.—Burgess-Manning Co., Penn Instruments Div., 4110 Haverford Ave., Phila. 4, Pa.

Circle **498** on inquiry card.

Data Recording Camera. New 2-page bulletin presents specs for 35-mm cine-interval camera sets for data recording.—Traid Corp., 17136 Ventura Blvd., Encino, Calif.

Circle **499** on inquiry card.

Tape Recorder. New 20-page Bulletin FR100 contains all information on maker's "FR100" instrumentation tape recorders used in data acquisition, storage, analysis and reduction, etc.—Ampex Corp., Instrumentation Div., 934 Charter St., Redwood City, Calif.

Circle **500** on inquiry card.

GAGING, TESTING, INSPECTION

Transistor Test Equipment. New 8-page Catalog 9-30-56 contains all information on maker's transistor test equipment, transistor power supplies, miniaturized components, constant current generators, etc.—Electronic Research Associates, Inc., 67-69 E. Centre St., Nutley, N. J.

Circle **501** on inquiry card.

Pinhole Detector. New 4-page Bulletin GEA-6520 provides the latest information on capabilities and operation of redesigned GE pinhole detector for automatically inspecting fast-moving opaque strip for small holes.—General Electric Co., Schenectady 5, N. Y.

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Comparator. New 2-page leaflet gives information on maker's bench-

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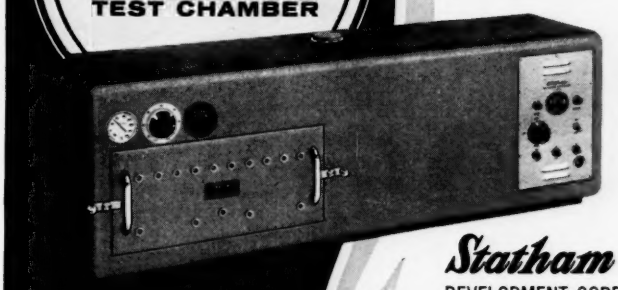

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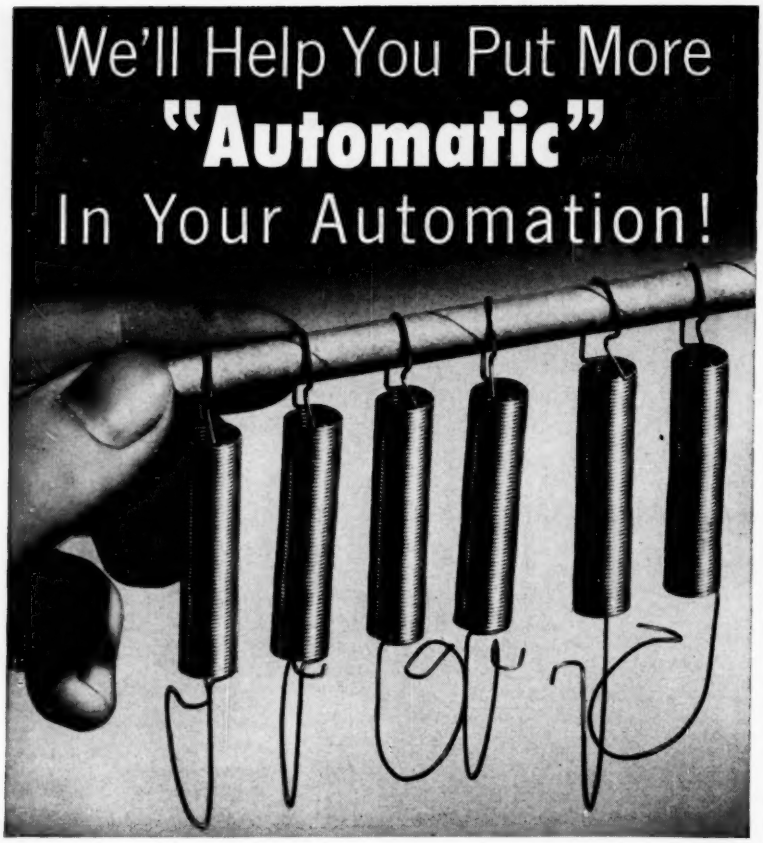

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NEW LITERATURE

type comparators for checking pitch diameters, lengths of parts, o.d. and i.d., etc.—Jerpbak Bayless Co., Solon Rd., Solon, Ohio.

Circle **503** on inquiry card.

Insulation Tester. New 8-page Bulletin 21-85 presents specs for several models of maker's "Megger", electrical insulation and resistance testers.—James G. Biddle Co., 1316 Arch Street, Phila. 7, Pa.

Circle **504** on inquiry card.

Alignment Testing. New 8-page reprint "Alignment Testing by K. J. Hume" describes and illustrates methods and instruments for alignment testing.—Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.

Circle **505** on inquiry card.

Compression Testing Machine. New 2-page illustrated bulletin pictures and describes maker's "Versa-Tester" Model AP-350 hydraulic testing machine.—Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.

Circle **506** on inquiry card.

Current Transformer Tester. New 4-page Bulletin 54-B shows operation of field set for testing grounds, shorts and high-resistance joints in current transformers.—Eastern Specialty Co., 3617 N. 8 St., Phila. 40, Pa.

Circle **507** on inquiry card.

Relay Testers. Two new 4-page bulletins describe and illustrate maker's electrolytic-capacitor, and universal relay testers. Includes 2-page price list.—The Magnavox Co., Dept. N. P., Fort Wayne 4, Ind.

Circle **508** on inquiry card.

Tube Analyzer. New 2-page bulletin describes maker's Thyratron and "Phanotron" tube analyzer.—Alectric Mfg. Co., 7842 - 39th Ave., Kenosha, Wis.

Circle **509** on inquiry card.

Torque Tester. New bulletin SD 35-53 presents information and data on maker's "Series A" OTT torque tester. Includes 8-page instruction manual.—P. A. Sturtevant Co., Addison, Ill.

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Illuminated Magnifier. New 12-page bulletin describes maker's "Flash-O-Lens" illuminated magnifier for inspection work.—E. W. Pike & Co., Inc., 492 North Ave., Elizabeth 3, N. J.

Circle **511** on inquiry card.

Dynamometers. New 4-page Bulletin B-12 describes maker's absorption dynamometers (water brakes); gives operating principle, design characteristics, specs and performance curves.—Industrial Engineering Co., Island Rd. and Suffolk St., Phila. 42, Pa.

Circle **512** on inquiry card.

Testing Equipment. New 52-page Catalog 21 discusses maker's testing equipment for cement, concrete, soils, bituminous and petroleum products.—Humboldt Mfg. Co., 2014 N. Whipple St., Chicago 47, Ill.

Circle **513** on inquiry card.

Monochromatic Lamps. New 4-page bulletin describes monochromatic lamps. 2-page bulletin presents specs

for optical flats.—Acme Scientific Co., 1450 W. Randolph St., Chicago 7, Ill.
Circle **514** on inquiry card.

Test Equipment. New 12-page illustrated bulletin pictures and describes maker's waveguide and coaxial test equipment.—Admittance-Namco Corp., Farmingdale, L. I., N. Y.
Circle **515** on inquiry card.

TUBING, FITTINGS

Adapter Fittings. New 12-page Catalog 4360 shows straight thread plugs and adapters, o-rings for straight-thread fittings, and steel and brass pipe fittings.—Tube & Hose Fittings Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.
Circle **516** on inquiry card.

Tubing Supports. New 20-page Bulletin 656-G provides data on maker's tubing supports and accessories.—P-W Industries, Inc., Duncan & Melrose Sts., Phila. 24, Pa.
Circle **517** on inquiry card.

Pipe, Tubing, Valves. New 12-page Brochure 51156 presents information on maker's corrosion-resistant thermoplastic pipe, tubing, ducting, valves and fittings.—American Agile Corp., 5461 Dunham Rd., Maple Heights, Ohio.
Circle **518** on inquiry card.

Teflon Tubing. New 4-page Bulletin T-50 describes maker's Teflon tubing, rod, sheet, steel pipe lining, insulated wire and machine parts.—Haveg Industries, Inc., 950 Greenbank Rd., Wilmington 8, Dela.
Circle **519** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Micro-Microammeters. New 2-page Data Sheet E-03-1 describes maker's micro-microammeters for nuclear reactor control systems.—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.
Circle **520** on inquiry card.

Audio Oscillator. New 2-page Bulletin 8549 describes and illustrates maker's "Audiolator" all-transistorized beat frequency audio oscillator, powered by mercury or penlight cell batteries.—Kay Electric Co., 14 Maple Ave., Pine Brook, N. J.
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Panel Meters. New 6-page Bulletin 2057 contains specs and prices for 800 models of panel meters, shunts and current transformers.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.
Circle **522** on inquiry card.

Frequency Meter. New set of 2-page Data Sheets furnishes specs, operation data, and uses of Type 504 Precision Heterodyne Frequency Meter; Standing Wave Detector, Type 219; and Klystron Power Supply, Type 809.—Polytechnic Research & Development Co., Inc., 209 Tillary St., Brooklyn 1, N. Y.
Circle **523** on inquiry card.

Oscilloscope. New 8-page brochure provides information and data on maker's "Type 515" wide-band oscilloscope.—Tektronix, Inc., P. O. Box 831, Portland 7, Oreg.
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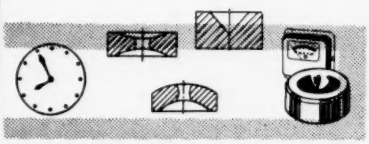

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NEW LITERATURE

DC Amplifier. New 4-page Bulletin CH374 describes and illustrates Hilger-Negretti d-c amplifier, an ultra sensitive, zero-drift galvanometer amplifier for measurement of extremely low currents and potentials.—Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

Circle **525** on inquiry card.

Autotransformer. New 24-page Bulletin O describes maker's "Variac" adjustable autotransformers.—General Radio Co., Cambridge 29, Mass.

Circle **526** on inquiry card.

Signal Generator. New 6-page bulletin presents specifications of maker's "Model SG-132" precision VHF-UHF signal generator and accessories.—Transitron, Inc., 186 Granite St., Manchester, N. H.

Circle **527** on inquiry card.

Frequency Converter. Three new 4-page Bulletins (176-12-56, 184-12-56, 185-12-56) presents information and data on maker's "Model 275" intermediate frequency converter; "Model 95" standard FM signal generator; and "Model 505" standard test set for transistors.—Measurements Corp., Boonton, N. J.

Circle **528** on inquiry card.

Electronic Instruments. New 48-page brochure presents data on maker's electronic instruments, controls, power supplies, etc.—Deltron, Inc., 2905 N. Leithgow St., Philadelphia 33, Pa.

Circle **529** on inquiry card.

Electron Microscope. New 12-page Brochure RC178 discusses construction and operation of maker's electron microscope and covers descriptions of all its components.—North American Philips Co., Inc., Instruments Div., 750 South Fulton Ave., Mt. Vernon, N. Y.

Circle **530** on inquiry card.

POTENTIOMETERS, RESISTORS

Precision Potentiometers. New 2-page Data Sheet 54-18 shows construction of maker's series B precision potentiometers, and gives specifications and characteristics.—Helipot Corp., a division of Beckman Instruments, Inc., Newport Beach, Calif.

Circle **531** on inquiry card.

High Frequency Resistors. New 8-page Bulletin F-la discusses types MP and HFR frequency & miniature high frequency resistors, including data on construction, characteristics, applications, types, resistance values, etc.—International Resistance Co., 401 N. Broad St., Phila. 8, Pa.

Circle **532** on inquiry card.

Trimming Potentiometers. Two new 2-page leaflets give electrical and physical specs, and describe Aero Electronics' miniature plug-in trimming potentiometers, Type G-525, and G-527.—Fred W. Falck Co., 2311 W. Burbank Blvd., Burbank, Calif.

Circle **533** on inquiry card.

Resistors, Rheostats. New 4-page Bulletin 53 contains ratings for fixed and adjustable vitreous enameled resistors and rheostats.—Hardwick, Hindle, Inc., 40 Hermon St., Newark 5, N. J.

Circle **534** on inquiry card.

TUBES, TRANSISTORS

Electron Tubes. New 4-page catalog presents list of maker's transmitting and industrial tubes for radio, industrial, and scientific uses.—BNC Industrial, 180 Spring St., Paterson 3, N. J.

Circle **535** on inquiry card.

Selenium Rectifiers. New 12-page Booklet 1007-10M pictures and describes maker's "Selenium Slims" union selenium power rectifiers.—Union Switch & Signal Div., Westinghouse Air Brake Co., Pittsburgh 18, Pa.

Circle **536** on inquiry card.

POWER SUPPLIES

Power Supply. New 2-page Bulletin 1570 describes and illustrates maker's "Type 3131" 26-volt d-c power supply.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

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Batteries. New 8-page brochure describes maker's "Sturges" nonspill storage batteries and cells.—Electronic Batteries, Inc., Bush Terminal

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Custom Power Supplies. New 18-page brochure shows examples of company's custom power-supply designs, including the following types: Magnetic-amplifier-regulated; transistorized; transistor-driven-mag-amp; dc to dc; saturable-reactor controlled; etc.—NJE Corp., 345 Carnegie Ave., Kenilworth, N. J.

Circle **539** on inquiry card.

SWITCHES, RELAY

Switches. New 32-page Manual GEA 6372 furnishes complete operation and application data for maker's manual, magnetic, and reduced-voltage starters; push buttons; relays; pressure and vacuum switches; float switches; solenoids; pressure governors etc.—General Electric Co., Schenectady 5, N. Y.

Circle **540** on inquiry card.

Relays. New 4-page brochure provides information on maker's a-c and d-c miniature relays for airborne electronics etc.—Union Switch & Signal Div., Westinghouse Air Brake Co., Pittsburgh 18, Pa.

Circle **541** on inquiry card.

Micro Switches. New 4-page issue of "Uses Unlimited" (Vol. 10, No. 3) contains information on new developments in company's line of micro switches. 2-page Data Sheet 115 describes Type 1RA1 subminiature screw driver-actuated switch.—Micro Switch, a division of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **542** on inquiry card.

Delay Relays. Two new 2-page Bulletins A.W.H. TD 404 and 405 describe maker's dial-adjustable time delay relays.—A. W. Haydon, Waterbury, Conn.

Circle **543** on inquiry card.

Switches. New 4-page Catalog 200 illustrates and describes maker's push button, lever, and turn switches.—Donald P. Mossman, Inc., Brewster, N. Y.

Circle **544** on inquiry card.

Precision Switches. New Haydon Switch-Idea File Catalog No. 5 provides data on maker's precision Switches for aircraft, industry, and commercial application including subminiature switches.—Haydon Switch Inc., Waterbury, Conn.

Circle **545** on inquiry card.

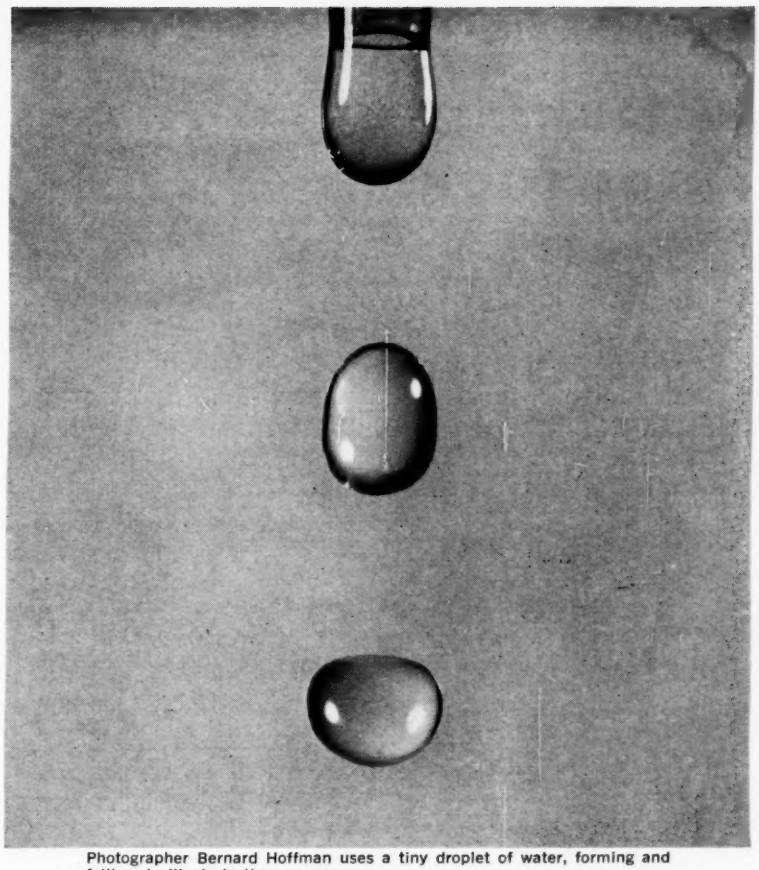
ELECTRICAL, ELECTRONIC COMPONENTS

Tubular Capacitors. New 8-page Bulletin GET-2671 lists ratings and dimensions for maker's molded "PVZ" tubular capacitors.—General Electric Co., Schenectady 5, N. Y.

Circle **546** on inquiry card.

Hermetric Terminals. New 4-page Bulletin LT-1 describes maker's "Type LT" seal terminals for hermetic sealing of electrical components.—International Resistance Co., 401 N. Broad St., Phila. 8, Pa.

Circle **547** on inquiry card.



Photographer Bernard Hoffman uses a tiny droplet of water, forming and falling, to illustrate time sequence.

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Transformers, Filters. New 47-page Catalog 571 presents list of maker's audio transformers, discriminators, filters, power components, etc.—Freed Transformer Co., Inc., 1718-1736 Weirfield St., Brooklyn (Ridgewood 27, N. Y.

Circle **548** on inquiry card.

Electronic Products. New 20-page Catalog No. 51 presents maker's new narrow neck disc cathode and, new cathode material "Cathaloy P-51", tubular electronics parts, cathode nickel alloys, glass sealing alloys, alloys for fabricated tubular parts, etc.—Superior Tube Co., 1566 Germantown Ave., Norristown, Pa.

Circle **549** on inquiry card.

Slip Rings. New 16-page brochure covers maker's slip rings, slip ring assemblies, microwave assemblies, and contact parts made from either laminated flat stock or raised lay.—D. E. Makepiece Co., Div. of Union Plate and Wire Co., Attleboro, Mass.

Circle **550** on inquiry card.

Vacuum Seals. New 12-page Catalog G-57 pictures and describes maker's glass-to-metal vacuum seals.—Glasseal Products Co., Inc., 1111 E. Elizabeth Ave., Linden, N. J.

Circle **551** on inquiry card.

Magnetic Coils. New 4-page folder describes company's facilities for producing special miniature magnetic coils.—Tur-BoJet Products Co., Inc., 424 South San Gabriel Blvd., San Gabriel, Calif.

Circle **552** on inquiry card.

NUCLEONICS

Reactors. New 2-page leaflet presents maker's mass-produced reactors including features, applications and general characteristics.—Aerojet-General Nucleonics, San Ramon, Calif.

Circle **553** on inquiry card.

Research Reactor Two new 4-page Bulletins, N-56-9 and N-59-8 describe a aqueous homogenous burner reactor, and a tank-type research reactor, resp., marketed by maker.—Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.

Circle **554** on inquiry card.

FABRICATION

Manufacturing Facilities. New 6-page Bulletin 154 offers information on company's equipment for shearing, punching and drilling, power forming, drawing.—Falstrom Co., 154 Falstrom Court, Passaic, N. J.

Circle **555** on inquiry card.

Cleaning Machine. New 4-page bulletin describes maker's industrial precision cleaning machine.—L & R Mfg. Co., 577 Elm St., Arlington, N. J.

Circle **556** on inquiry card.

Bevel Protractor. New 2-page illustrated bulletin describes maker's universal bevel protractor.—George Scherr Co., 200 Lafayette St., New York 12, N. Y.

Circle **557** on inquiry card.

Pliers. New 2-page Leaflet P1 53 pictures and lists sizes of various Swedish pliers.—B. Jadow, Inc., 860 Broadway, New York 3, N. Y.

Circle **558** on inquiry card.

Wire Wrapping Tools. New 4-page Brochure 5205 pictures and describes maker's wire-wrapping tools for elec-

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NEW LITERATURE

trical connections in radio, TV, etc.—Ingersoll-Rand, 11 Broadway, New York 4, N. Y.

Circle **559** on inquiry card.

Soldering Tips. New Catalog No. 144 shows an expanded line of Hexclad Long-Life Soldering Tips with 40 stock sizes and shapes and many special styles to choose from.—Hexacon Electric Co., 179 W. Clay Ave., Roselle Park, N. J.

Circle **560** on inquiry card.

Lubricators. New 2-page data sheet presents description of maker's semi-automatic push-type lubricators.—Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, N. J.

Circle **561** on inquiry card.

Mechanized Heat Treating. New 8-page Bulletin SC-176 presents 24 basic furnace mechanisms, diagrams and photos to illustrate steps to a completely mechanized heat treat line.—Surface Combustion Corp., Toledo 1, Ohio.

Circle **562** on inquiry card.

Ultrasonic Cleaner. New 4-page Bulletin GW 45 contains all information on maker's "Model GW-5 and GW-4" ultrasonic instrument bearing and small parts cleaners.—The Baker Co., Inc., Maplewood, Maine.

Circle **563** on inquiry card.

Rolling Mills. New 12-page reprint "Rolling Mills for Processing Nuclear Fuel Elements", discusses special equipment employed in rolling and fabricating new metals required for atomic energy program.—Stanat Manufacturing Co., 500 Shames Dr., Westbury, N. Y.

Circle **564** on inquiry card.

Manufacturing Facilities. New 12-page brochure describes company's electronic research, development, and production facilities.— Nelson Instrument Co., 607 Howard St., Evanston Ill.

Circle **565** on inquiry card.

MATERIALS

Permanent Magnets. New 4-page Technical Bulletin DMF-3 on new Alnico 5 Cb permanent magnet material gives its physical properties, dimensional limitations, and typical curves, and comparison figures with other such materials.—Thomas & Skinner, Inc., 1120 E. 23rd St., Indianapolis 7, Ind.

Circle **566** on inquiry card.

Magnetic Shielding. New 68-page brochure describes maker's non-shock sensitive, non-retentive, magnetic shielding material.—Magnetic Shield Div., Perfection Mica Co., 20 N. Wacker Drive, Chicago 6, Ill.

Circle **567** on inquiry card.

Laminated Metals. New 16-page Catalog "Mill Products" gives all information on company's solid and laminated flatstock, raised and spotlay stock, solid and laminated tubing, wave guide tubing, precious-metal wires, and solders.—D. C. Makepiece Co., Div. of Union Plate and Wire Co., Attleboro, Mass.

Circle **568** on inquiry card.

Insulating Materials. New 32-page Catalog 20 contains descriptions, photos, prices, ordering data, etc. on electrical insulations for repair and maintenance of motors, generators, and electrical or electronic equipment.—Insulation Manufacturers Corp., 5656 W. Washington Blvd., Chicago 6, Ill.

Circle **569** on inquiry card.

Epoxy Resin Adhesives. New 11-page bulletin presents engineering data on maker's high-strength epoxy resin adhesives for metal to metal bonding, etc.—Adhesives and Coatings Div., Minnesota Mining and Mfg. Co., 423 Piquette Ave., Detroit 2, Mich.

Circle **570** on inquiry card.

Carboloy Blanks. New 35-page Price List GT-314 covers maker's line of carbide blanks.—General Electric Co., Metallurgical Products Dept., Detroit 32, Mich.

Circle **571** on inquiry card.

Silicone Lubricants. New 8-page brochure provides data on maker's silicone lubricants.—Dow Corning Corp., Midland, Mich.

Circle **572** on inquiry card.

MECHANICAL COMPONENTS

Mechanical Components. New 4-page bulletin presents ideas, techniques and designs of maker's mechanical components used for mounting, housing, fastening of electronic equipment.—Alden Products Co., 127 N. Main St., Brockton, Mass.

Circle **573** on inquiry card.

Ball Bearings. Three new 2-page bulletins describe maker's SS 2C radial retainer and size 814 ball bearings.—Miniature Precision Bearings, Inc., Precision Park, Keene, N. H.

Circle **574** on inquiry card.

Fasteners. New 4-page catalog covers the design and manufacturing advantages of cold headed fasteners and parts.—John Hassall, Inc., Westbury, L. I., N. Y.

Circle **575** on inquiry card.

Cable Trough. New 12-page Bulletin 256-F presents information and data on maker's "Cabletrof"" for supporting control and power wiring.—P-W Industries, Inc., Duncan & Melrose Sts., Philadelphia 24, Pa.

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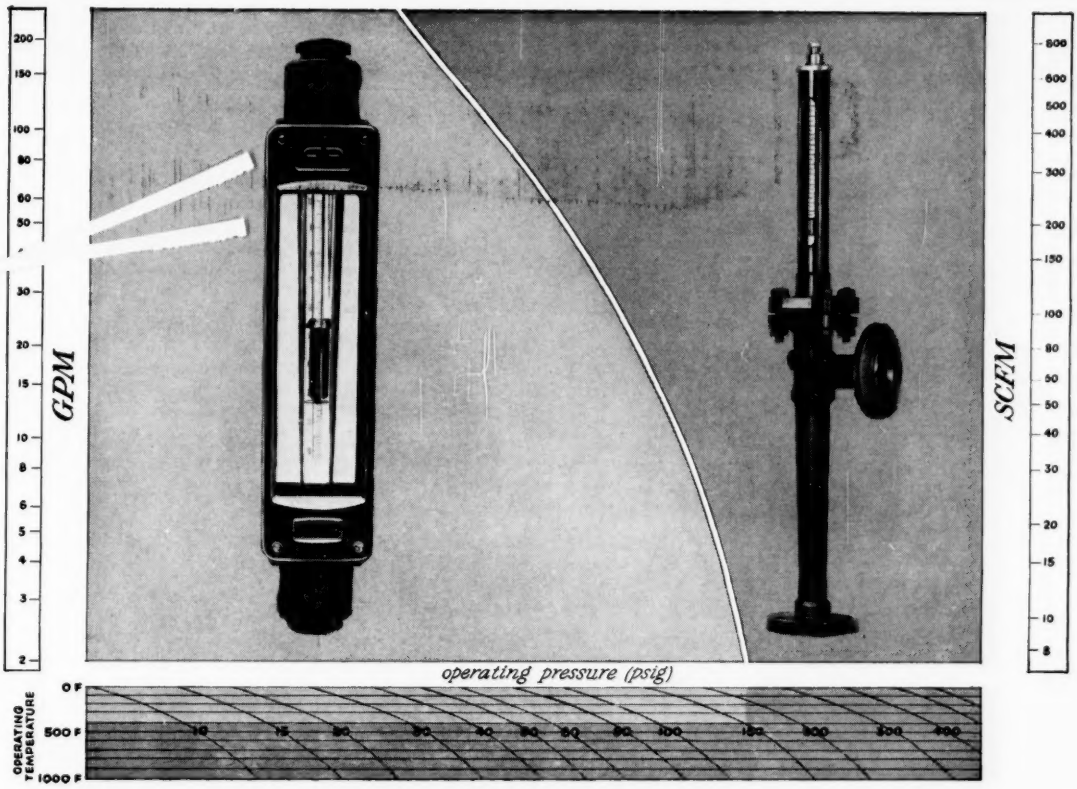

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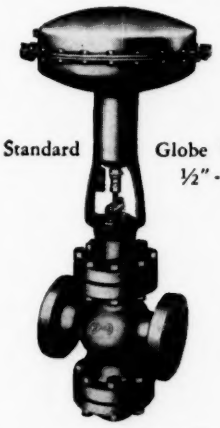

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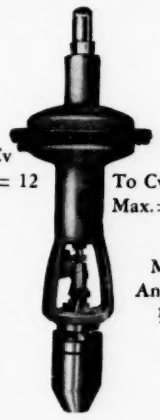

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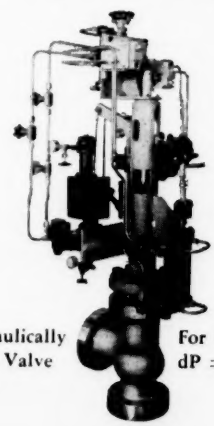

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